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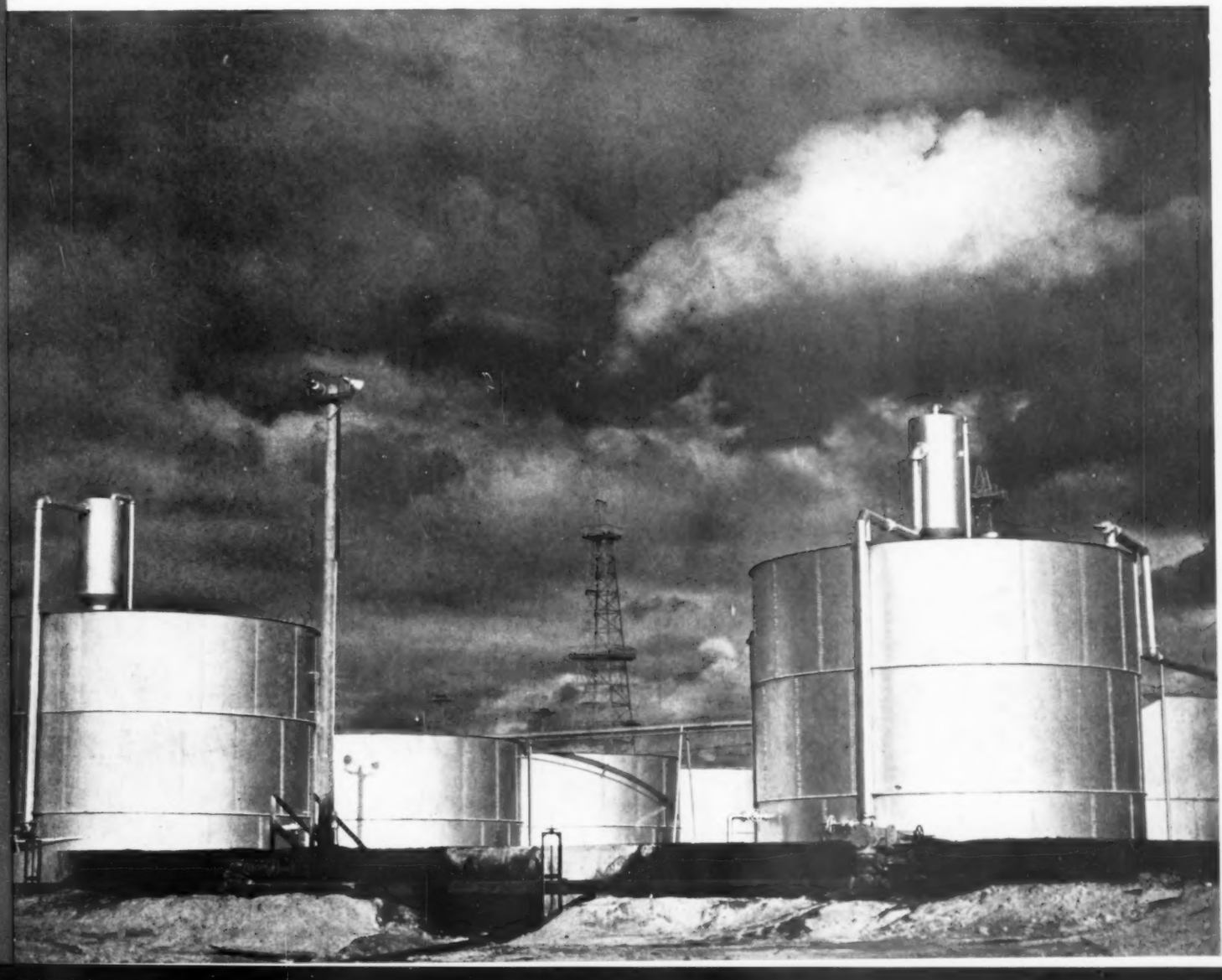

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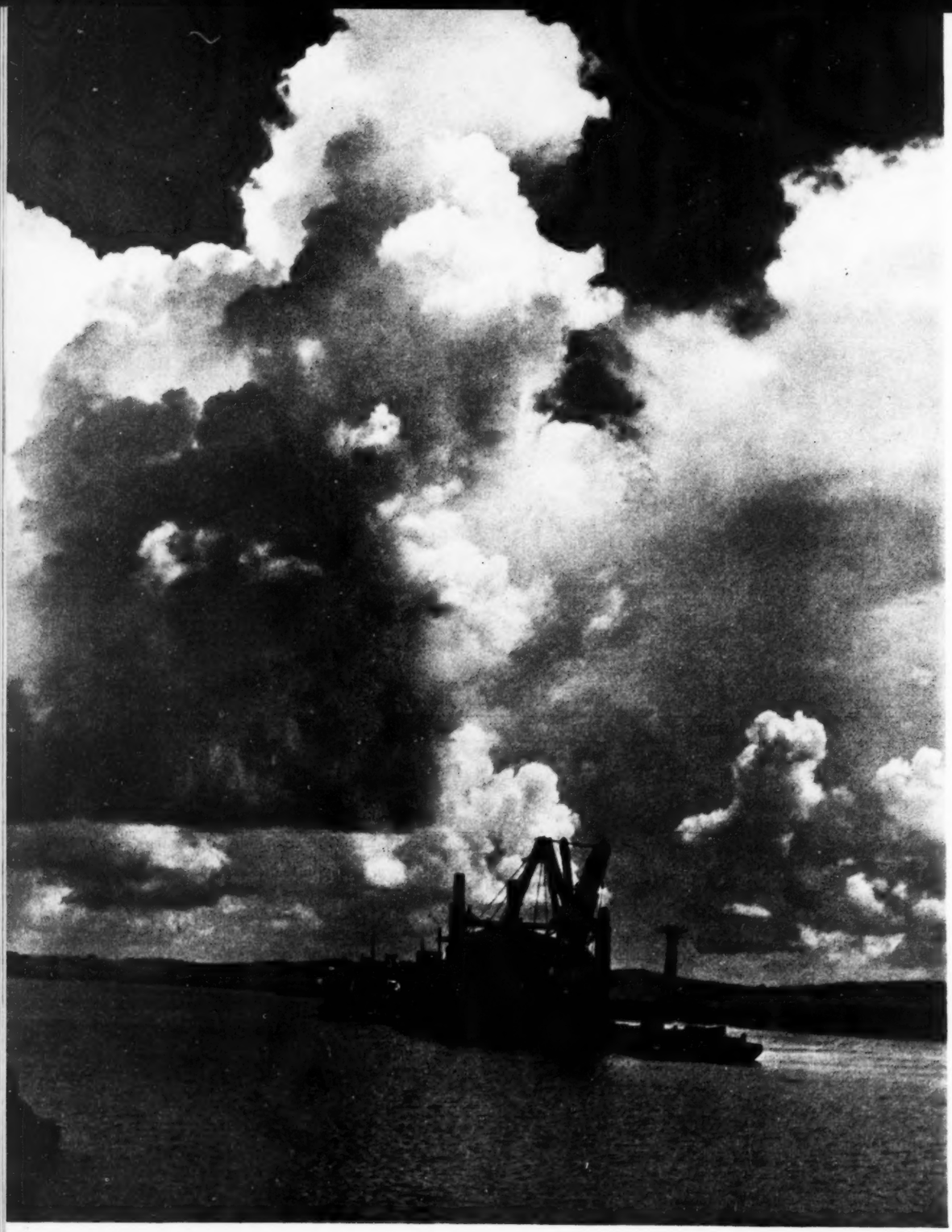


Photo by Cy La Tour & Son

Dredging the intercoastal canal along the Texas-Louisiana Gulf coast.

EDITORIAL

OIL INDUSTRY'S PROGRESS IN 1938

WHILE 1938 has been a year of disappointments and sacrifices for the oil industry of the United States it has been also a season of substantial advancement. This has been evidenced, not merely in technical improvements which are continually under way, but also in the ability of the industry to cope with economic difficulties. This always has been the weak spot in its armor.

In the exuberance induced by the rapid upswing in demand for petroleum products during the first half of 1937 crude production was pushed up to a record figure of over 3,700,000 barrels a day in August of that year. This high point was reached just at the time when the acute slump in general business began to make itself widely felt. This 1937 business decline, which critics of the federal administration tagged as the Roosevelt depression, was exceptional in its suddenness and its severity. Financial analysts tell us that the drop in industrial activity was one of the most precipitate ever recorded. Before the oil industry could begin to adjust itself to this swift change stocks had mounted dangerously, unneeded supplies of products were pressing on the markets and the whole price structure was in a precarious condition.

During the winter months of each year stocks of motor fuel customarily accumulate and usually reach their top in March, at the beginning of the season of heavier motor travel. In the spring of 1938 the accumulation of motor fuel stocks reached its apex with 93,000,000 bbl. on hand or nearly 20,000,000 bbl. above the 1937 top. Since the annual consumption of motor fuel in this country is something over 500,000,000 bbl. this meant that slightly less than four percent of the year's requirements already had been manufactured—accepting the 1937 peak supply as merely normal. Four percent was about the extent of increase in 1938 demand over 1937 that had been forecast as probable by a number of competent trade observers. As time went on, however, and a further decline in industrial activity replaced the expected recovery it became evident that there was to be no appreciable gain in motor fuel consumption. The problem became one, not of holding production down to the level of 1937 requirements, but of bringing it below that level if the threatening excess of existing stocks was to be liquidated.

Thus was created a situation in which, so claimed the advocates of federal control of petroleum, any state and voluntary system of regulation inevitably would break down and the strong hand of national authority would be needed to bring order out of the resultant chaos. Among the economic planners in Washington it was confidently expected that such a chaotic condition would follow immediately upon the Supreme Court's invalidation of the National Industrial Recovery Act in May 1935. When it did not occur at that time they amended their forecast by predicting that federal intervention would become necessary whenever the oil industry experienced the first serious setback to its expansion.

It must be admitted that the forces working to maintain a reasonable degree of stability in the oil industry have faced tremendous difficulties during the year. This has been due to lack of adequate and sufficient implements for the task. The Interstate Compact, by its very nature as a voluntary organization, is limited in the influence it can exert. At times during the year it has seemed that the Compact itself might be disrupted. The rise of production in states outside its sphere has served also to lessen the effect of its pronouncements. Lack of proration laws in these states has made it impossible for state officials to place a restraining hand on the expansion of output.

The device formerly employed at the urging of federal officials for relieving pressure of unneeded supplies upon the market by inducing companies with large marketing organizations to take these over was not available this year. Having listened to the pleas of one group of federal officials to absorb distress offerings, only to be rewarded by criminal prosecution at the hands of another division of the same federal administration, the companies naturally were of no mind to repeat the experience and the market was left to shift for itself, except for such relief as individual companies felt disposed to extend. Such purchases have been an important sustaining factor, particularly in the past few weeks.

With supply continuing to outrun demand and no avenue of relief available for weakly held refined products the price of gasoline began to give way. Numerous refineries shut down and others curtailed their runs. Pipe lines were forced to prorate their takings. For a long time after conditions became acute nominal quotations for crude remained at their former levels but in almost every field sales were being made at substantial discounts. Ultimately the market was forced to adjust itself to realities by a general lowering of crude prices.

Throughout this period the regulatory bodies of those states which have conservation laws on their statute books have worked steadily to keep production from rising to a point that would involve serious waste, and in states where such laws are lacking voluntary efforts have been exerted by members of the industry to the same end. Because of its preponderant position as a producer Texas has been the keystone of the whole structure. The Railroad Commission of that state has acted with courage and ability in meeting the situation and by so doing has carried the support of the vast majority of producers in the state, despite the hardships and losses that many of the latter have had to undergo.

As a result of the efforts that have been put forth the petroleum industry of the United States approaches 1939 in a far stronger position and with a far better outlook than at the beginning of 1938. Overground stocks of crude oil are less than at any previous time since 1923. Stocks of gasoline are approximately the same as a year ago while daily runs to stills are 150,000 bbl. less. If production and runs are kept normally close to current requirements for the next five months motor fuel supplies at the beginning of next summer will present no cause for embarrassment. Stocks of fuel oil are still abnormally high but should be materially reduced during the next few months.

Even greater encouragement is to be found in the fact that the tide of industrial activity is now rising and not ebbing as was the case a year ago. The Federal Reserve index of industrial production which fell from 117 in August 1937 to 84 at the end of the year and subsequently receded to 76 in May 1938 was back to 96 in October. How long this improvement will continue or how far it will carry it is impossible of course to say. Many commentators on industrial and financial conditions hold to the belief that little further progress is to be expected for the next few months, but that a period of sustained advance will set in early in the spring of 1939. A special factor affecting the outlook for motor fuel is the marked increase in automobile production and sales. Based upon motor vehicle sales during the past two months it has been estimated that at least a four percent increase in motor fuel demand is to be anticipated in 1939. If general industrial recovery materializes it should raise this substantially.

In considering the developments of the current year it would be a mistake not to include among the heartening signs of progress what may best be described as the growing spirit of accommodation within the industry and among the various groups that it comprises. This has revealed itself in many practical ways; in the readiness of the larger companies to provide outlets for wells orphaned by the closing down of refineries on which they had depended; in the willingness of so-called independents and majors to sit down together to compare their respective viewpoints, and in the growing tendency to consider all questions that arise with due regard to the interests of all those affected. This spirit of fairness and good will found outstanding expression at the recent annual convention of the American Petroleum Institute in Chicago and is the feature of that meeting that has received most wide and favorable comment.

The most important issue before the oil industry of the United States remains, as it has been for the past several years, that of its right to manage its own affairs, subject only to such checks as may be deemed necessary to insure fair play in all commercial operations. Oil will continue to suffer attack from politicians intent on self-exploitation and from economic theorists immersed in plans for a vast bureaucracy to rule all industry. To retain its right of self control it must demonstrate its ability to handle internal problems as they arise, to serve the public and the country well. It has met the test during the past year under particularly difficult conditions. The next step should be to strengthen the means by which it can deal with similar problems in the future. That needs a strongly united industry.

INCREASE IN U.S. OIL EXPORTS

Felt Mainly In Refined Products*

Crude Oil Shipments Increasing Due to Stimulus of Refining in Countries Overseas—Greater Purchases of Natural Gasoline Probably Caused by Requirements of Military and Civil Aviation.

DURING the first nine months of 1938, United States export trade in petroleum products was characterized by extreme variations. These variations ranged from an increase of 74 percent in the case of natural gasoline to a decrease of 64 percent in exports of liquid petroleum gases.

Exports of crude continued to increase totaling 60,006,000 bbl. compared with 48,769,000 bbl., an increase of 23 percent over 1937. Exports of liquid refined products (excluding natural gasoline, benzol, bunker fuel oil and greases) although shipped in greater quantities in 1938, did not approach the gains made by crude oil. Total liquid refined products exported during the first nine months of 1937 was 70,455,000 bbl. against 76,773,000 bbl. during 1938 or a gain of about nine percent.

Increased refinery development abroad appears primarily responsible for the growth in America's crude exports and the continuous lessening of refined oil trade. The chief customers for crude oil continued to be Canada and Japan who bought 18,876,000 and 17,835,000 bbl. respectively, while France took 12,479,000 bbl. In the 1937 period, these countries, in the same order, received 21,794,000 bbl., 10,746,000 bbl., and 7,059,000 bbl.

Conforming to the general annual trend exports of gasoline in bulk have shown a 31 percent increase, while shipments of gasoline in containers suffered an 11 percent loss. Chief buyers of bulk gasoline in both 1937 and 1938 were the United Kingdom, Netherlands West Indies and the Netherlands. These countries took 5,785,000 bbl., 2,025,000 bbl., and 1,488,000 bbl. respectively in 1938. Total exports for the first three quarters of 1938 were 28,314,000 bbl. as compared with 21,642,000 bbl. for 1937.

As a purchaser of U.S. gasoline in containers, Japan jumped from third place in 1937 with 95,000 bbl. to first place in the current period with 232,000 bbl. Brazil, formerly America's chief customer with 268,000 bbl., dropped to second place in 1938 with 135,500 bbl.

Natural gasoline showed the greatest percentage increase of all petroleum products exported. In this trade, the figure for the first nine months of 1938 amounted to 4,344,000 bbl., a 74 percent increase over 1937. Netherlands West Indies, a world transshipment point, took 1,266,671 bbl. in the nine months under review or almost double its share during the previous period. The United Kingdom also contributed to the increase trade by taking 794,175 bbl. compared with 633,339 bbl. Canada fell from second to third place being the recipient of 630,000 bbl. against 682,000 bbl. for the corresponding three quarters of 1937. France more than doubled her purchases of natural gasoline, taking 551,000 bbl. in the 1938 period while Japan took 369,000 bbl. or over three times her share of the previous year. Customers which did not appear on the books in 1937 are U.S.S.R. with 330,000 bbl., Spain 43,000 bbl., and Italy 4,000 bbl. There is a possibility that this increased demand is to satisfy the growing requirements of military and civil aviation abroad.

The notable decrease in export trade in "naphtha, solvents, and other light products" by 42 percent was due mainly to the complete failure of Italy to order any of this product. Turkey stepped from a comparatively remote rating to first place, taking 201,000 bbl., while the United Kingdom placed second with 176,000 bbl.

Exports of mineral spirits continued to be small, amounting to only 87,000 bbl. in the first three quarters of 1938, but the 24 percent increase is an encouraging indication. Australia continues as principal user of this commodity.

A 16 percent decrease in exports of kerosene in bulk was noted at 5,010,000 bbl. for the period under review. Netherlands West Indies which was the destination of 1,002,000 bbl. was relegated to second place by the United Kingdom with 1,215,000 bbl. Trade with China fell off from 798,000 bbl. to 19,000 bbl. in the first three quarters of 1938, while the Netherlands halved its trade to 411,000 bbl.

An increase of two percent brought exports of gas and distillate fuel oil to a total of 22,351,000 bbl. in the first nine months of 1938. Netherlands West Indies took the leading position with 4,581,000 bbl., followed by Japan with 4,043,000 bbl. and Germany with 3,112,000 bbl. Gas oil, of increasing importance both from a military and industrial standpoint as well as for cracking stock for conversion to gasoline, ranks third in quantity of petroleum exports, being exceeded only by crude and gasoline.

The United States' export trade in residual fuel oil for the first nine months of 1938 showed a 22 percent gain over the corresponding months of 1937. Expressed in quantities, the 1938 period is credited with 11,000,000 bbl. Trade with Japan, although totaling only 2,208,000 bbl. in 1938 against 3,620,000 bbl. was still the principal source of revenue from fuel oil. Next in order came Chile and Cuba taking 1,665,000 bbl. and 1,143,000 bbl. respectively.

Taken as a group, sales of bunker oil, gas oil, distillate fuel oil and residual fuel oil, exceeded any other single classification —with a total of 61,204,000 bbl. in the first nine months of 1938 compared with 59,692,000 bbl. in the corresponding period of 1937. Although obviously not the highest in value consumption of this grade is rapidly increasing.

Exports of Petroleum and Petroleum Products

	Jan.-Sept. 1937	Jan.-Sept. 1938	Change (Percent)
	(Barrels)		
Crude Petroleum	**48,769,000**	**60,006,000**	**+23**
Motor Fuel	**27,158,000**	**34,728,000**	**+28**
Natural gasoline	2,498,000	4,344,000	+74
Gasoline in bulk	21,643,000	28,314,000	+31
Gasoline in conteiners	1,863,000	1,119,000	—11
Naphtha	1,338,000	774,000	—42
Benzol	416,000	177,000	—57
Mineral Spirits	**70,000**	**87,000**	**+24**
Kerosene:	**6,648,000**	**5,510,000**	**—17**
In bulk	5,929,000	5,010,000	—16
In containers	719,000	500,000	—30
Gas Oil and Distillate Fuel Oil	**21,886,000**	**22,351,000**	**+ 2**
Residual Fuel Oil	**9,326,000**	**11,378,000**	**+22**
Bunker Oil:	**28,480,000**	**27,575,000**	**— 3**
American vessels	12,941,000	10,888,000	—16
Other vessels	15,539,000	16,687,000	+ 7
Lubricants:	**8,537,000**	**7,413,000**	**—13**
Red and pale oils	5,192,000	4,274,000	—18
Black oils	471,000	334,000	—29
Bright stock	1,334,000	1,193,000	—11
Steam refined stocks	812,000	773,000	— 5
Transformer and insulating oils	23,000	21,000	— 8
Small packages	19,000	18,000	— 5
Oils not elsewhere specified	430,000	627,000	+46
Greases, all kinds	256,000	173,000	—32
	(Pounds)		
Liquid Petroleum Gases	**8,223,000**	**3,015,000**	**—63**
Paraffin Wax	**174,241,000**	**140,987,000**	**—19**
Unrefined	76,148,000	65,115,000	—14
Refined	98,093,000	75,872,000	—23
	(Long Tons)		
Asphalt:	**153,000**	**155,000**	**+ 1**
Petroleum Coke	**121,000**	**83,000**	**—30**

* Compiled by the Fuels Section, Metal and Minerals Division, Bureau of Foreign and Domestic Commerce, Washington, D. C.

*This article has been based on information supplied by the Fuels Section, Bureau of Foreign and Domestic Commerce, Washington, D. C.

Exports of all lubricants, including greases converted to barrels in the nine months period under review were 7,413,000 bbl. a decline of 13 percent from 1937. Red and pale lubricating oils, the most important items in this classification, decreased 18 percent to 4,274,000 bbl. Bright stock, the next item of importance in the lubricating oil classification, showed a loss of 11 percent.

Exports of unclassified lubricating oils, showing an increase of 46 percent, were the only bright feature in the lubricants group. The quantities were not large, amounting to 627,000 bbl. in the 1938 period.

The greatest percentage loss among lubricant exports appeared in lubricating greases, the sales sinking by 32 percent because of greatly decreased purchases by United Kingdom, Japan, Belgium and Germany.

Kerosene in containers, exports of which have likewise been diminishing in recent years, showed a decrease of 30 percent; from 719,000 to 500,000 bbl. for the two comparative periods under discussion. Few generalizations can be drawn as this trade includes so many countries; the outstanding points are reduction of Brazil's patronage by 45 percent to 157,000 bbl., the complete disappearance of Gold Coast from the 1938 books (48,000 bbl. in 1937), and appearance of Dominican Republic.

The most drastic decline in the United States trade in petroleum products during the first three quarters of 1938 occurred in liquid petroleum gases, amounting to 63 percent, when 8,223,000 bbl. were exported. The outstanding loss occurred in the case of France, which took 6,146,000 lb. in the previous period and practically none in the first three quarters of 1938. The United Kingdom, Italy, and Bermuda greatly reduced their purchases while Canada, Mexico and Germany gave needed encouragement to this trade by increasing their procurements.

Total paraffin wax exports showed a decline of 19 percent, from 174,241,000 lb. in the first three quarters of 1937 to 140,987,000 lb. in the like period of the present year. Trade in refined wax showed the greatest decrease, at 23 percent, while trade in unrefined paraffin wax was slightly less discouraging with 14 percent loss.

The export figure for all types of asphalt rose by about one percent. Petroleum coke, on the other hand, suffered a 30 percent setback.

WESTERN Hemisphere Dominates European Market

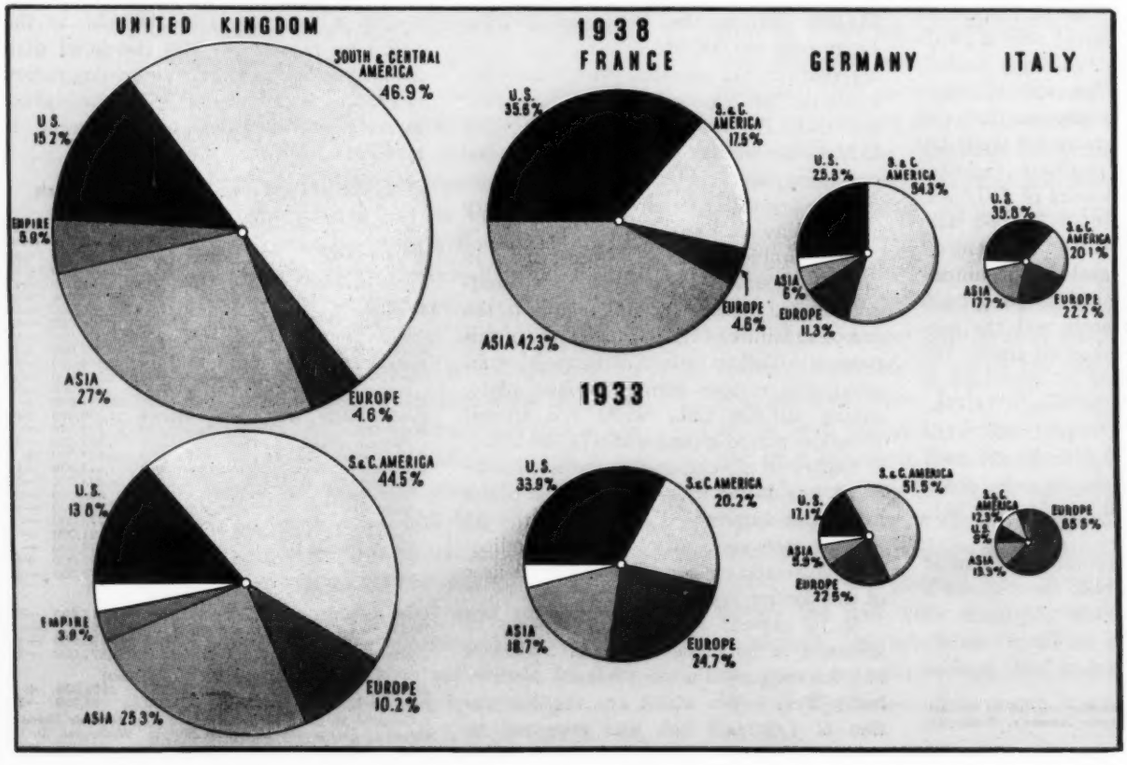
By Dr. Kurt Lang

DURING the past few years European oil imports have undergone considerable changes in their source. A striking feature of this shift is that imports from European sources, which previously reached a peak of 24.7 percent of the total, fell to 15.9 percent in 1937 while the exporting countries of the western hemisphere improved their positions in the European markets and have acquired more than 50 percent of all European import business.

In this shift the continual increase in Europe's oil consumption has played a large part; in the past five years the increase of imports into the most important European countries has been no less than 41 percent.

The reasons for this change in the import market are many and various, and have even overturned old and previously well established importing connections based on strong financial ties between the importing countries and their suppliers.

Among the causes at work is the falling output of the old European oil-producing



Distribution of oil imports into the chief European countries according to countries of origin—the situation in the first half of 1933 is compared with the first half of 1938. The four countries represented absorb nearly 80 per cent of the total European oil imports and are therefore fairly representative.

regions on the one hand, and on the other hand the inability of local production to increase in proportion to the growth of local demand. This latter phase of the matter appears most clearly in the case of the U.S.S.R. In 1933 the Russians could export 23 percent of their production, but in spite of a 33 percent increase of production during the past five years, their domestic consumption increased so much that they now have hardly seven percent available for export. This change in Russian conditions and the increase of consumption in the importing countries had the result of demoting Russia from second place in the Italian market and third place in the French, German, Czechoslovak markets. Russia now figures least in the import statistics of those countries, and since 1933 has had a much smaller participation in the oil trade of the border states and Scandinavia.

The decrease of Roumanian production and exports set in later than in Russia, and has been quite noticeable in Western Europe, while the unimportant Polish exports in the meantime ceased altogether. With the exception of Albania, which delivers exclusively to Italy; this exhausts the list of European oil exporting countries.

Against this retrogression of exports from the old European producing countries there indeed stands a constant increase of production in Middle Europe, especially in Germany, including Austria and Hungary. But in none of these countries does the increase in production bear any noteworthy ratio to increase in local consumption. The oil output in the importing European countries with inadequate petroleum industries of their own has up to the present had an influence only on lubricating oil imports. Throughout Europe the tendency has been to work up the domestic production as far as possible into lubricants which have the highest values, although their cost of production is also high.

The reduced imports of lubricating oils that have resulted from this policy have had relatively the smallest effect on imports of American lubricating oils, which, because of their unmatched high quality, are the most difficult with which to dispense.

As regards the artificial production of petroleum, which in Germany has so greatly increased and is still increasing, this can be neglected in view of the general situation. Even in that country, which is making such strenuous efforts toward oil autarchy, total imports still show a steady increase, which means that the demand is growing at a faster rate than the artificial oil industry.

Of equal importance in this shifting of the sources of supply is the policy, first initiated by France, of replacing imports of finished products by imports of crude oil for refining within the importing country. The French example has been followed by other large consuming countries, such as Germany and Italy, and even smaller consuming countries like Sweden and Portugal.

As a result of such movements the crude oil imports of the most important European countries have risen from 22 percent of total imports of mineral oil in 1933 to 39 percent in the first half of 1938. The newer producing countries have been able to increase their shipments of crude to Europe.

In its capacity as crude oil supplier the United States has also increased its deliveries to Europe because the trend toward increasing imports of crude oil has involved certain important changes in the complexion of the import markets. Since the imported crude oil is worked to the fullest possible extent into the most valuable product—gasoline—imports of gas oil and fuel oil have overshadowed (in quantity) the imports of finished gasoline, and not every country which exports finished products has been able to adapt itself conveniently to this trend of consumption. The United States has been best able to do this —being the greatest producing, refining and consuming country in the world, the United States export trade has the greatest elasticity as regards finished products.

Political influences and strategical supply viewpoints have also combined to effect a certain regrouping of the sources from which oil supplies are drawn. Contrasting political and economic circumstances have led the western powers to adopt an importing policy different from the autarchic policies of the authoritarian states; their trade tends to follow their political sympathies, especially in those directions from which the largest supplies may be obtained in times of conflict. England and France, the two countries which are the largest importers of mineral oil, have committed themselves in case of war to deliveries from overseas. It is natural that as the danger of conflict becomes more imminent they should direct most of their current business to those quarters on which they would have to place the most reliance in wartime. The plan to build a strategic pipeline in France from the mouth of the Loire to the center of the country shows that the French are putting autarchy aside in favor of imports. Since in the case of war the United States and South America will obviously be the major source of supply, the French are already adjusting themselves to the situation, and in general favor deliveries from North America, Venezuela and Colombia.

The United States is the most important supplier of high grade aviation gasoline and its export trade has benefited considerably from this situation. The qualitative superiority of American lubricating oil and the qualitative superiority of American gasoline have greatly contributed to strengthen the position of the United States as a supplier to the European countries.

Again, economic-political considerations have played a large part in regrouping the sources of supply. Roumania has lately redoubled its efforts to place its oil exports in those countries where the consumers pay in funds that have a high exchange value; in spite of the higher freight costs the Roumanians are endeavoring to avoid clearing transactions as much as possible.

The general result of these movements in Europe, which are continually operating to increase the inflow of crude oil instead of finished products, and to limit the latter as much as possible to goods of especially high quality, may be expected to continue. This means that deliveries from the United States will increase. This conclusion is all the more reasonable from the fact that while the European producing countries have been increasing their consumption, their production has further declined, and some of the larger suppliers of crude oil have turned to refining their output.

The accompanying graphs show the distribution of the oil imports of England, France, Germany and Italy—the four largest European importing countries—according to the countries of origin.

Between 1933 and 1937 the United States increased its proportion of the trade of the neutral countries chiefly at the expense of the U.S.S.R., and in 1938 had 32 percent of the Belgian, 28 percent of the Dutch, 36 percent of the Swiss and Swedish and 25 percent of the Norwegian imports. In the border states, where Russian influence still predominates although continually decreasing, the United States delivers about 20 percent of the imports. In middle Europe (except Germany) particularly in the Balkans, transportation conditions give Roumania predominance in the import figures; but where difficulties in trade with Roumania exist as in Austria before the *Anschluss*, imports from the United States are filling the breach.

It is rather difficult to specify exactly the participation of each supplying country in the trade of each European importing country, because the oil import statistics of many countries do not always reveal the country of origin. However, for 1937 it is estimated that Venezuela occupied first place (28 percent) in European oil imports; then followed the United States with 21 percent, having moved up from third place (16 percent) in 1933.

The importance of the United States as an oil supplier to Europe has thus increased, and from what has been set forth above its importance in this regard is destined to become greater.

FIVE BILLION Barrels Geophysically Discovered at Cost of $100,000,000

By V. G. Gabriel

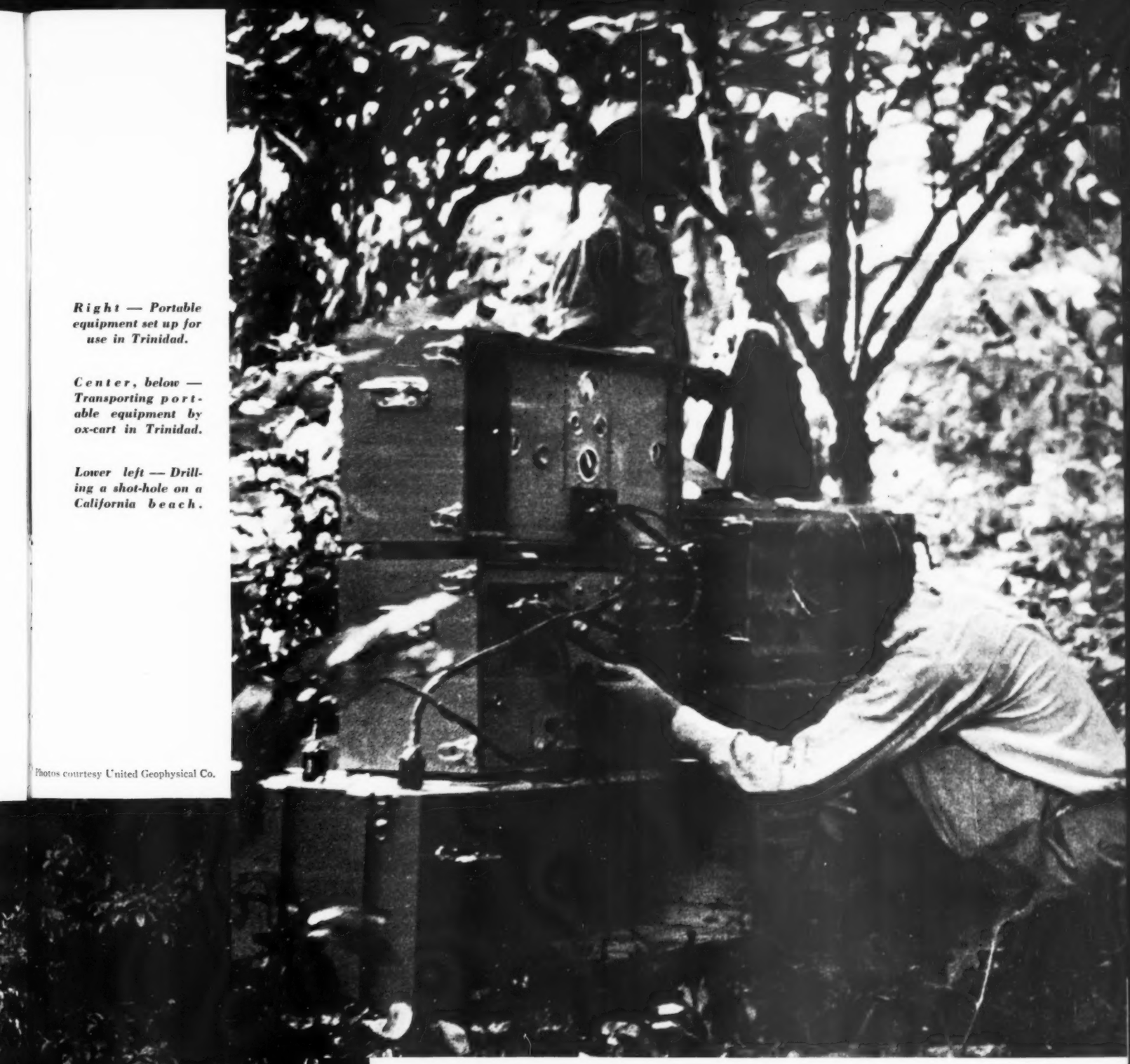
THE value of geophysical prospecting should be judged not only in terms of oil discovered by its application, but, to some extent, by substantial savings on unnecessary leasing and drilling. It is reasonable to assume that without geophysical prospecting the burden of leasing and paying for land which has no oil possibility, would be too heavy for many oil companies.

Oil suitable for commercial exploration is found in the United States under various underground stratigraphical and structural conditions and depths ranging from 50 ft. in the Camarillo oilfield, California, to over 13,000 ft. in the West Dulac field, Terrebonne Parish, Louisiana. By observation and by study we are accustomed to associate the occurrence of natural oil pools with salt domes, anticlines, monoclines, fault zones and faults, volcanic plugs, unconformities and synclines under special conditions, etc. More than a decade ago Munn and Rich and quite recently Levorsen then later Pratt, Rosaire, and others were stressing the importance of stratigraphic associations for the location of new oil pools.

The geophysical methods which are being used in the United States in exploration for oil can be subdivided into three broad groups as follows: (1) methods for detection of oil directly; (2) mixed methods; (3) methods for detection of favorable oil structures and stratigraphic conditions. It is of interest to note that only one geophycical method, soil analysis, is entirely concerned with the direct detection of oil without additional claims of being useful for the detection of favorable structures and stratigraphic conditions.

Until 1920 no geophysical methods had been used in the United States in exploration for oil. Beginning in 1921 one or two organizations did some work of rather experimental nature on the application of some principles of geothermal gradients and radioactivity to oil finding. In 1922 the torsion balance, in 1923 the seismograph, and around 1924 the magnetometer and the electrical methods were introduced into the United States. At the end of 1924 Cunningham Craig wrote, "Of recent years much attention has been given by physicists to the perfection of instruments to record minute differences in gravity and other physical quantities . . . the torsion balance has perhaps attracted most interest and has given the most striking results. This method has been used extensively in connection with petroleum work in the plains of Hungary and other countries. . . . There is at least one authenticated case of an oilfield (the Egbell field) discovered by this method. . . ." By the end of 1926 the torsion balance was given credit for the discovery of Nash, Long Point, Clemens, and Allen, the salt domes of shallow type in the Gulf Coast area, and numerous geophysical prospects. By 1926 over 300 men were connected with the geophysical exploration for oil in the United States and at the end of 1926 Pratt reported, "There is something new under the sun. . . . A new salt dome has actually been discovered without any well having been drilled to prove the discovery. . . . This is tantamount to the assertion that our confidence in the seismograph (refraction method) in geophysical exploration has already come to be perfect. . . . In the present instance the favorable area has been entirely leased and royalties have been bought and sold on a price basis nearly, or quite nearly equal

Photos



Right — Portable equipment set up for use in Trinidad.

Center, below — Transporting portable equipment by ox-cart in Trinidad.

Lower left — Drilling a shot-hole on a California beach.

Photos courtesy United Geophysical Co.

to that which would have prevailed had a well actually been completed in salt or cap rock. The new dome . . . will probably be called the Moss Bluff Dome." In December of 1926 Ball wrote, "The world's first department of geophysics is being established at the Colorado School of Mines under Dr. C. A. Heiland."

The years of 1927, 1928, and 1929 showed great popularity of seismographs, torsion balances, and magnetometers, and in 1929 over 1,300 men were connected with 30 seismic, 50 torsion balance, 125 magnetometer, and 10 miscellaneous parties and general research laboratories all pertaining to the search for oil in the United States.

Rosaire and Stiles, Barton, and others in their studies of the Gulf Coast salt dome area gave full credit to either seismic or torsion balance prospecting or both for the finding of 37 oilfields, between 1927 and 1929. Also Barton gives a detailed table pertaining to the oilfields discovered during 1929 on geophysically discovered salt domes or salt structures in the Gulf Coast area as follows: five discovered by

torsion balance; four discovered in Texas by seismograph; six discovered in Louisiana by seismograph.

The years of 1930, 1931, 1932 showed a marked curtailment in geophysical exploration in the United States. Even in the Gulf Coast area only three oilfields were found by geophysics in 1930, two fields in 1931, and four in 1932. In 1931, one of the less active years in geophysical prospecting, approximately only five seismic, 25 torsion balance, a few electrical magnetic, and miscellaneous parties and research groups totaling not over 450 men were engaged in geophysical prospecting for oil in the United States. However, Wasson, in his paper on oil discoveries in southeastern Illinois, states, "At first the reconnaissance torsion balance survey made in 1930 . . . indicated . . . a gravitational disturbance west of Olney. . . . The seismograph work checked the existence of a structural disturbance extending across Wayne, Richland, and Jasper counties. Drilling has so far confirmed the geophysical work. . . ."

It is of interest to note that the magnetometer takes partial credit for the finding of the Buckeye and Ferguson's Crossing oilfields, of Texas, discovered in 1931 and 1933 respectively.

Beginning in 1933 the revival of the application of geophysical method in exploration for oil became more noticeable. In 1933 approximately 1,550 men were engaged in geophysical exploration in the United States whereas in 1937 over 4,000 men were employed by numerous geophysical field parties and laboratories. The last few years have been well marked with a wider use of geophysical methods not only in Texas and Louisiana, but also in California, Arkansas, Kansas, Rocky Mountains district, Illinois, Oklahoma, and many other states.

Rosaire and Stiles, in their study of the Gulf Coast area, gave credit to seismic and torsion balance surveys for the finding of the Bosco, Splendora, Vanderbilt, Ferguson's Crossing, Valentine, and Nome oilfields and prospects found in 1933 of the Hastings, Anahuac, Lafitte, South Houston, Pickett Ridge, Mauritz, East Bernard fields found in 1934, and of the Tepetate, Cheneyville, Big Lake, Bayou Mallet, Turtle Bay oil fields found in 1935.

Bush, in his study on the development in Oklahoma for 1936, stated, "Eleven gas wells and 23 oil wells were discovered by wildcat exploration in Oklahoma in 1936. Exploration was carried on in large part by geophysical methods."

A seismograph crew operating out of small boats in the beautiful bayous and swamps of Southern Louisiana.

Photo courtesy Independent Exploration Co.

Nowlan gave credit to geophysics for the finding of six oilfields out of 29 new pools discovered in 1936 in South Texas.

Moulton stated in his study of the Illinois basin discoveries, "The reflection seismograph is probably the most important method of petroleum exploration which has recently been brought into the Illinois Basin. . . . The discovery within a short time of the Patoca, Cisne, Clay City, and Noble fields all of which are located on structures found through the use of reflection seismograph. . . ."

Edwards and Hoots recognized the importance of geophysical exploration in the recent discoveries of oil in California. Hoots stated, "Nine new fields, new zones in three fields and one geological extension of an older field were discovered in California in 1937. These discoveries and normal extensions of existing fields added an estimated 322,000,000 bbl. to the state reserve oil supply. . . . The success of these two years (1936 and 1937) is a deserved testimonial to the ability of the geological profession . . . and the adoption of more effective methods of exploration—particularly the use of reflection seismograph . . . also partly to magnetometer." In general, out of 14 oil and a few gas fields discovered in California in 1936 and 1937, the credit for discovery should be given to geophysics in at least nine; seven by seismograph; one by electric resistivity method and by magnetometer; and one by application of seismic and geological methods.

At the present time we have in the United States two departments of geophysics, one at the Saint Louis University under Dr. Macelwane and the other at the Colorado School of Mines under Dr. Heiland, exclusively devoted to the training in the fundamentals of general and applied geophysics. Also California Institute of Technology, Harvard, Columbia University, Massachusetts Institute of Technology, Michigan School of Mines and Technology, Pennsylvania State College, Rice Institute, University of California, and many other institutions offer many courses pertaining to general and applied geophysics.

SEISMIC PROSPECTING

Seismic prospecting is based on the principle of propagation of elastic waves generated by artificial explosions and on their reflection and refraction at the boundary planes separating strata of different elastic properties. Prior to 1930 the principle of refraction was widely used in search of oil. Recently, however, the principle of reflection has much wider application in geophysical prospecting for oil in the United States.

The cost of keeping a seismic party in

the field and the amount of work being accomplished by a party depends upon many factors and conditions such as topography, the presence of good roads and solid ground, climate, underground seismic conditions, and on the type of information expected of the seismic survey. It should be remembered also that the cost of necessary research and office work is usually added to the normal upkeep of a seismic party.

According to Barton, DeGolyer, and others, the cost of a refraction seismic party in the Gulf Coast area prior to 1930 was between $15,000 to $18,000 per month with an average cost ranging from five cents to $0.12 per acre, or a more common cost of $0.08 per acre. The detailing of salt dome was usually at a cost from $3.00 to $5.00 per acre. Later the introduction of the reflection method greatly reduced the cost of modern seismic prospecting. The cost of a reflection seismic party is usually accepted as not over $10,000 per month and much less with favorable conditions. The acre cost of seismic exploration work is a subject of wide variation. For example, the average cost of seismic prospecting in the Texas Gulf Coast area for 1937 was estimated at $1.61 per acre, whereas the average cost of seismic reconnaissance in Kansas and Nebraska in 1936 was assumed by Lee and Baugham to be $0.18½ per acre. The cost per seismic station is also a subject of variation. According to the writer's recent experience with seismic reflection surveys in Louisiana, Mississippi, and Texas, the cost of a single station, of one profile, may vary from $150, when only two seismic profiles a day are taken, to $25 per seismic profile or station when more are taken.

It is somewhat difficult to evaluate exactly the amount of money spent in the United States on seismic exploration for oil. However, the study of the seismic activities from 1923 to 1937, inclusive, indicates that approximately $69,000,000 was spent in the United States on seismic exploration during that period, or subdivided as follows: $2,500,000 from 1923 to 1925, $14,600,000 from 1926 to 1930, $21,700,000 from 1931 to 1935, and $30,000,000 in 1936 and 1937. The exact evaluation of oil discovered in the United States by the application of seismic methods is somewhat difficult because many publications pertaining to the description of newly discovered fields often give credit to geophysics in general for a seismic discovery. Therefore a large measure of credit should be given to the seismograph for the discovery up to July, 1937, of 38 oilfields in South Texas credited wholly or partly to geophysics, and for numerous geophysical prospects still undrilled. In California too the seismograph should be given whole or partial credit for the discovery of over six oil and gas fields with the total estimated oil reserves of over 200,000,000 bbl. In Arkansas the seismograph took some part in the discovery of three fields in 1936 and 1937 with an ultimate oil recovery estimated at over 210,000,000 bbl. In North Louisiana and East Texas the seismograph should be given a large measure of credit for the discovery of 12 oilfields attributed wholly or partly to geophysical exploration. The seismograph is also responsible for numerous discoveries made in Illinois, Kansas, Oklahoma, Rocky Mountain oil district, North Central Texas, West Texas, and other states and districts. The geophysical table attached to this article gives detailed information pertaining to the oilfield discoveries and to the amount of oil found by seismic exploration methods in the Gulf Coast area before the middle of 1938. It shows a grand total of 1,198,600,000 bbl. as the approximate amount of crude oil discovered by seismic exploration methods in the Gulf Coast area. Assuming that the expenditure on seismic explora-

Photo courtesy American-Askania Corp.

Operating a magnetometer.

Shooting a small charge of dynamite in seismic prospecting.

Courtesy United Geophysical Co.

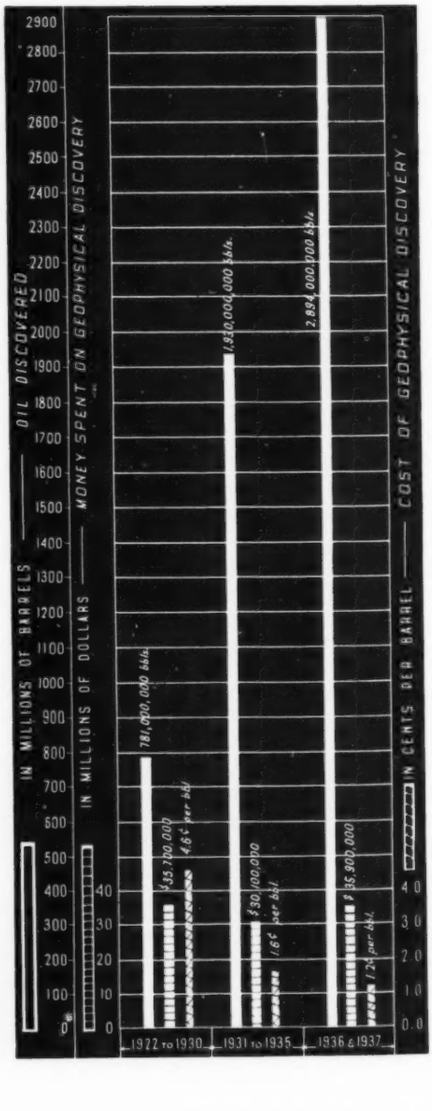
tion up to the beginning of 1938 in the same area was approximately $33,000,000, we obtain that the average cost of discovery per barrel of oil by seismograph in this area was equal to 2.7 cents per barrel.

GULF COAST AREA

Fields Discovered Wholly or Partly by Geophysics

(To July 1, 1938)

Field and County	Discovery	Production to July 1, 1938	Method
TEXAS GULF COAST			
AUSTIN CO.			
New Ulm	1934	.....	Geophysics & Geology
BRAZORIA CO.			
Bryan Mound	1935	.....	Reflection Seismic
Danbury	1930	43,000	Seismic & Geology
Manvel	1931	12,488,000	Geology, Tortion Balance & Seismic
Old Ocean	1934	1,357,000	Reflection Seismic
Pledger	1932	.....	Reflection Seismic & Tortion Balance
Sandy Point	1937	105,000	Reflection Seismic & Tortion Balance
Allen	1927	88,000	Tortion Balance
Austin Bayou	1930	.....	Tortion Balance
Hastings	1934	12,500,000	Tortion Balance
Lockridge	1936	1,000	Tortion Balance
CHAMBERS CO.			
Anahuac	1935	8,710,000	Reflection Seismic, & Tortion Balance
Cedar Bayou	1937	1,000	Reflection Seismic
Cotton Lake	1936	619,000	Reflection Seismic & Tortion Balance
Lost Lake	1929	912,000	Seismic & Gas Seeps
Seabreeze-Willow Slough	1934	143,000	Reflection Seismic & Tortion Balance
South Cotton Lake	1936	.....	Reflection Seismic & Tortion Balance
Turtle Bay	1935	680,000	Reflection Seismic & Tortion Balance
Cedar Point	1938	40,000	Tortion Balance
COLORADO CO.			
Garwood	1932	2,000	Tortion Balance, Geology, Magnetometer
FORT BEND CO.			
Orchard	1926	3,380,000	Refraction Seismic
Long Point	1928	.....	Tortion Balance
Nash	1926	1,668,000	Tortion Balance & Geology
Sugarland	1928	26,761,000	Tortion Balance
Thompsons	1931	27,691,000	Geology & Tortion Balance
GALVESTON CO.			
Dickinson	1934	4,058,000	Reflection Seismic & Tortion Balance
Green's Lake	1936	35,000	Reflection Seismic & Tortion Balance
Hitchcock	1937	53,000	Reflection Seismic & Tortion Balance & Geology
HARDIN CO.			
Ariola	1932	1,780,000	Seismic
Silsbee	1936	718,000	Tortion Balance
Clinton	1936	46,000	Tortion Balance & Reflection Seismic
Eureka	1934	85,000	Tortion Balance & Seismic
Fairbanks	1938	112,000	Tortion Balance & Reflection Seismic
Friendwood	1937	420,000	Tortion Balance & Seismic, Geology Gravimeter
Mykawa	1929	3,267,000	Tortion Balance & Geology
Setsuma	1936	215,000	Tortion Balance
South Houston	1935	3,851,000	Tortion Balance & Reflection Seismic
Tomball	1933	10,070,000	Tortion Balance & Geology
HARRIS CO.			
Clear Lake	1938	.....	Reflection Seismic
Fairbanks	1938	112,000	Reflection Seismic & Tortion Balance
Eureka	1934	85,000	Tortion Balance, Seismic, Geology, Gravimeter
HOUSTON CO.			
Kitrell	1934	.....	Geology, Geophysics
JEFFERSON CO.			
Amelia	1936	2,069,000	Reflection Seismic & Tortion Balance
Cheek	1938	20,000	Reflection Seismic & Tortion Balance
Clam Lake	1937	16,000	Reflection Seismic
Fannett	1927	2,312,000	Refraction Seismic
Jefferson Coast	1938	.....	Reflection & Refraction, Seismic, Geology, Tortion Balance
Nederland	1937	.....	Reflection Seismic
North Cheek	1937	54,000	Reflection Seismic & Tortion Balance
West Beaumont	1936	604,000	Geophysics
Labelle	1937	104,000	Tortion Balance
Nome	1936	901,000	Tortion Balance & Geology
LIBERTY CO.			
Cleveland	1933	996,000	Refraction Seismic, Tortion Balance, Pendulum
Hardin	1935	1,052,000	Geology, Check by, Reflection Seismic
Moss Bluff	1929	180,000	Refraction Seismic
Esperson	1929	5,036,000	Tortion Balance
Hankamer	1929	5,122,000	Tortion Balance
MATAGORDA CO.			
Hawkinsville	1925	.....	Reflection Seismic
McCroskey-Armour	1938	1,000	Reflection Seismic
Palacios	1937	70,000	Reflection Seismic
Simonville-Robbins Ranch	1938	.....	Reflection Seismic
South Bay City	1936	372,000	Reflection Seismic
Van Vleck	1934	1,557,000	Geology, Reflection Seismic
Wilson Creek	1937	.....	Reflection Seismic
Mad Island	1930	.....	Tortion Balance
Sheppard's Mott	1935	2,000	Tortion Balance & Geology
MONTGOMERY CO.			
Conroe	1931	92,718,000	Geology & Refraction Seismic
Magnolia	1938	.....	Reflection Seismic, Tortion Balance & Geology
Splendora	1934	1,000	Reflection Seismic
NEWTON CO.			
Call	1937	10,000	Reflection Seismic & Tortion Balance
Sabin Tram Block	1937	.....	Reflection Seismic & Tortion Balance
ORANGE CO.			
Port Neches	1929	4,693,000	Refraction Seismic
POLK CO.			
Segno	1936	789,000	Refraction Seismic & Tortion Balance
Gold Spring-Evergreen	1936	.....	Geology & Geophysics
Ace	1933	114,000	Tortion Balance & Trend Play
Livingston	1932	4,646,000	Tortion Balance & Geology
TYLER CO.			
Spurger	1937	191,000	Reflection Seismic & Tortion Balance
Katy	1935	.....	Reflection Seismic
San Felipe	1934	21,000	Seismic
WHARTON CO.			
Five Corners	1936	.....	Reflection Seismic & Tortion Balance
Blue Basin	1937	.....	Reflection Seismic & Tortion Balance
Louise	1933	1,990,000	Refraction Seismic
Picket Ridge-Kubela	1935	1,689,000	Reflection Seismic & Tortion Balance
Spanish Camp	1936	.....	Reflection Seismic & Geophysics
Withers	1936	1,166,000	Reflection Seismic & Tortion Balance
Magnet	1934	291,000	Tortion Balance



Field and County	Discovery	Production to July 1, 1938	Method
LOUISIANA GULF COAST			
ARCADIA PARISH			
Bayou Mallet	1934	141,000	Reflection Seismic & Tortion Balance
Bosco	1934	16,110,000	Refraction Seismic
North Crowley	1937	168,000	Reflection Seismic, Geology, Gravimeter
South Crowley	1938	2,000	Reflection Seismic & Tortion Balance
Tepetate	1935	4,738,000	Reflection Seismic & Tortion Balance
Oberlin	1938	.....	Geophysics
ASCENSION PARISH			
Sorrento	1928	860,000	Geology & Refraction Seismic
Darrow	1932	1,631,000	Tortion Balance
ASSUMPTION PARISH			
Napoleonville	1926	.....	Geology & Seismic
BEAUREGARD PARISH			
Bancroft	1938	.....	Pendulum
English Bayou	1935	.....	Reflection Seismic & Tortion Balance
Gillis	1933	14,673,000	Geology, Seismic & Tortion Balance
Iowa	1929	32,096,000	Seismic, Tortion Balance & Geology
Starks	1927	2,477,000	Refraction Seismic
CAMERON PARISH			
Black Bayou	1929	5,367,000	Geology, Seismic
Big Lake	1935	66,000	Reflection Seismic
Calcasieu Lake	1927	.....	Seismic
Cameron Meadows	1931	5,650,000	Geology, Seismic & Tortion Balance
Creole	1938	23,000	Reflection Seismic
East Hackberry	1927	20,155,000	Refraction Seismic & Geology
Gulf Of Mexico Block "2"	1936	.....	Reflection Seismic
EAST BATON ROUGE PARISH			
University—S. B. Rouge	1938	34,000	Reflection Seismic
EVANGELINE PARISH			
Ville Platte	1937	303,000	Reflection Seismic, Geology & Tortion Balance
IBERIA PARISH			
Fausse Point	1927	62,000	Refraction Seismic
Jefferson Island	1938	3,000	Reflection Seismic & Geology
Vermillion Bay	1938	.....	Seismic
JEFFERSON PARISH			
Lafitte	1935	9,830,000	Reflection Seismic
JEFFERSON DAVIS PARISH			
Roanoke	1934	6,726,000	Seismic, Tortion Balance, Geology
South Elton	1937	11,000	Reflection Seismic
South Jennings	1936	6,000	Reflection Seismic & Tortion Balance
IBERVILLE PARISH			
Bayou Blue	1929	75,000	Seismic
Bayou De Glaise	1926	.....	Seismic
Choctaw	1931	1,950,000	Refraction Seismic
White Castle	1926	2,536,000	Refraction Seismic
South Roanoke	1937	24,000	Reflection Seismic
Woodlawn	1938	20,000	Reflection Seismic & Tortion Balance
LAFOURCHE PARISH			
Chacahoula	1926	.....	Reflection Seismic & Geology
Lake Long	1937	195,000	Reflection Seismic
Leesville	1931	18,604,000	Seismic
Marchand	1937	.....	Refraction Seismic
Raceland	1938	94,000	Reflection & Refraction Seismic & Geology
Timballer Bay	1938	34,000	Reflection Seismic & Gravimeter
Valentine	1936	1,872,000	Reflection Seismic
PLAQUEMINE PARISH			
Bird Island	1938	.....	Reflection Seismic
Garden Island Bay	1935	1,468,000	Refraction Seismic
Lake Hermitage	1934	115,000	Refraction Seismic
Lake Washington	1931	2,276,000	Refraction Seismic & Geology
Potash	1937	1,000	Refraction Seismic
Quarantine Bay	1937	107,000	Reflection Seismic & Gravimeter
Venice	1937	358,000	Refraction Seismic
ST. CHARLES PARISH			
Bayou des Allemands	1937	62,000	Refraction & Reflection Seismic
ST. JAMES PARISH			
Convent Hester	1936	.....	Tortion Balance & Reflection Seismic
ST. LANDRY PARISH			
Cankton	1936	.....	Reflection Seismic & Geology
Port Barre	1929	7,083,000	Refraction Seismic
ST. MARTIN PARISH			
Henderson	1937	.....	Reflection Seismic
Lake Mongouloui	1936	.....	Tortion Balance
St. Martinsville	1935	68,000	Reflection Seismic, Tortion Balance & Geology
ST. MARY PARISH			
Bateman Lake	1937	74,000	Reflection Seismic
Charenton	1936	664,000	Reflection Seismic, Tortion Balance & Geology
Horseshoe Bayou	1937	159,000	Reflection Seismic
Jeanerette	1935	4,565,000	Reflection Seismic & Geology
TERREBONNE PARISH			
Bay St. Elaine	1929	73,000	Seismic
Caillou Island	1930	19,334,000	Refraction Seismic
Dog Lake	1929	1,342,000	Refraction Seismic
East Bay Junop	1927	.....	Refraction Seismic
Four Isle	1934	293,000	Refraction Seismic
Gibson	1937	898,000	Reflection Seismic
Lake Barre	1929	16,621,000	Seismic
Lake Pelto	1929	965,000	Refraction Seismic
Lirette-Houma Gas F.	1937	35,000	Reflection Seismic, Tortion Balance & Geology
West Dulac	1937	500,000	Reflection Seismic
VERMILLION PARISH			
Abeville	1937	123,000	Reflection Seismic
Gueydan	1932	810,000	Refraction Seismic
Intercoastal City	1937	.....	Reflection Seismic
West Gueydan	1938	.....	Reflection Seismic

TORSION BALANCE

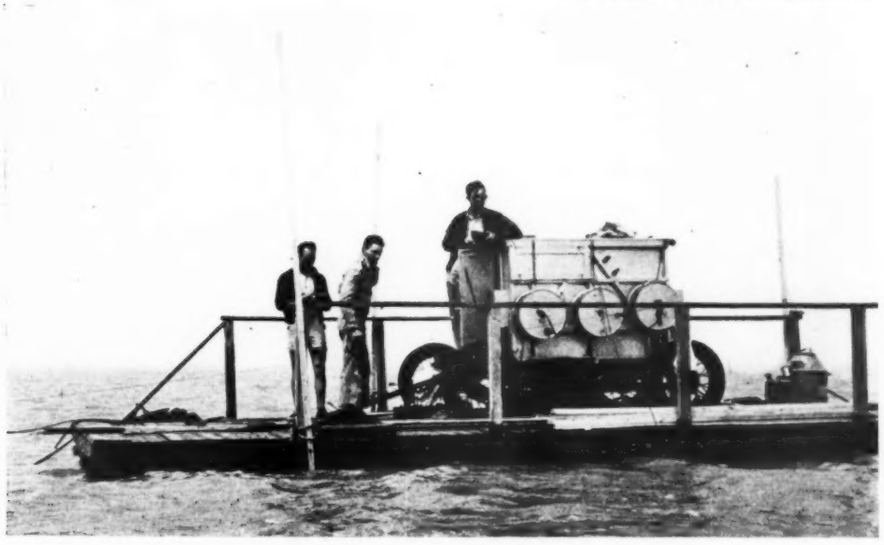
Torsion balance prospecting is based upon the principle of gravity and certain relationships existing between the rate of change in gravity in the horizontal direction, obtained by the torsion balance at the stations of observation, and favorable oil structures and stratigraphic conditions. The first torsion balance was designed by Baron Eotvos, a Hungarian scientist, about 1887. Years later many minor improvements by technical and scientific workers made the torsion balance suitable for exploration for oil.

There is much variation in the cost of torsion balance exploration. This variation depends upon many factors and conditions such as topography, good roads, solid ground, climate, organization, and the information expected of the survey. De Golyer in 1932 gave $4,500 per month as the cost of keeping a torsion balance party in the field with an average cost of $24-$25 per station and $0.05 per acre. In the same year, Barton gave $12-$15 as the average cost per torsion balance station. Jenny, also in 1932, wrote "in reconnaissance survey . . . an average cost of torsion balance station in dry territory of the Gulf Coast is $25 . . . three torsion balance parties covering 50 sq. mi. a month at the expense of $2,500 counting three stations per day per balance." In 1935 Clark wrote "torsion balance crew usually of four instruments and from nine to 15 men . . . 300-400 stations per month with an average cost of $15 per station." Stubbe recently wrote " . . . with two torsion balance instruments of new type . . . it is possible to cover 275 to 300 stations per month . . . at the cost of $7.00 to $7.50 per station."

According to the writer's personal experience in torsion balance prospecting, the cost per station, even in the same territory, depends to a large extent upon party organization, salaries paid, number of instruments in the party, and the type and quality of information desired of the survey.

It is somewhat difficult, as in the case of seismic prospecting, to evaluate exactly the role played by the torsion balance in the discoveries of new oilfields and oi reserves. Unquestionably some measure of credit should be given to the torsion balance for the discovery of some oil fields now credited to geophysics. The geophysical discovery table accompanying this article gives somewhat approximate although detailed information pertaining to the oilfield and oil reserve discoveries in the Gulf Coast area which are attributed to the application of the torsion balance. This table shows that approximately 986,000,000 bbl. of crude oil can be counted as a result of such exploration in that area. Assuming that $13,000,000 out of $21,000,000 spent on torsion balance exploration in the United States represents the expenditure in the Gulf Coast area, we

Seismograph instrument trailer mounted on a barge for work in shallow bays.
Photo courtesy Independent Exploration Co.



obtain one and a third cents, or less thna two cents, as the average cost of discovery per barrel of oil by the torsion balance in the Gulf Coast.

Gravimetric and pendulum prospecting are based on the principle of gravity and its relationship to the favorable oil structures and stratigraphic conditions.

PENDULUM

The pendulum has been used by the United States Coast and Geodetic Survey for the evaluation of regional structures and conditions prior to the introduction of the torsion balance into the United States. With the introduction of the torsion balance a few major oil companies began to use the pendulum in prospecting. In spite of its reasonably creditable record, the pendulum was never as widely used as the torsion balance or the modern gravimeter.

GRAVIMETER

Gravimetric prospecting has a long record in the United States. Until about 1936, however, it was used sparingly, as in the case of the pendulum. Beginning in 1936 the introduction of the modern gravimeter by American and other inventors gave strong impetus to its use for exploration for oil in the United States. According to Steinmann and others, four gravimeters in 1935, fourteen in 1936, and 27 in 1937 were used in the United States for exploration.

The modern gravimeter is a very fast and reasonably accurate instrument. On an average, it is able to survey from 20 to 25 stations a day. Under favorable conditions, its speed is even much higher. The average cost per station in gravimetric surveying ranges from $4.50, or less, to $8.00. De Golyer gives $30 to $40 per station and $0.07 per acre as the cost of pendulum prospecting prior to 1931.

It is somewhat difficult to evaluate exactly the role played by the pendulum and the gravimeter in the discovery of new oil reserves in the United States. Some credit should be given to the gravimeter and the pendulum in the discovery of new oil and gas fields credited to geophysics in general. The accompanying geophysical discovery table gives, somewhat approximately, an evaluation of the oil discoveries made by gravimetric and pendulum methods in the Gulf Coast area and in south Texas.

This table credits pendulum and gravimetric prospecting with the discovery of 108,200,000 bbl. of crude oil in the Gulf Coast area. The total expenditure in the United States on both methods might be taken to equal over $3,000,000.

MAGNETOMETER

Magnetic prospecting is based upon the difference in magnetic properties of rocks and strata due to the dissemination of minerals of different magnetic susceptibilities and their relationship to structures and stratigraphic conditions. The first magnetometers were introduced into the United States about 1924 and until 1930 were widely used in exploration for oil. After 1930 to 1935 there was a curtailment in the use of magnetometer in the United States. Recently certain improvements pertaining to the old-type Schmidt magnetometer and the introduction of micromagnetometers by American and designers abroad served as an impetus to the broader use of magnetometers.

The cost of magnetic surveying depends, to a large extent, on the presence of good roads, weather, climate, and the information desired of the survey; $1.15 to $1.40 is set as an average cost per magnetic station in many surveys conducted by consulting geophysical companies. The writer still remembers his experience of making only seven or eight magnetic stations per day on foot and in snow in Colorado where a few months before 25 to 30 stations a day was his usual average. About $4,500,000 has been spent on magnetic prospecting in exploration for oil in the United States. The geophysical table gives some data pertaining to the oilfields discovered by the magnetometer in the Gulf Coast, and south Texas.

ELECTRICAL

Electrical prospecting is based upon the principle of introduction of electric and electromagnetic fields into the earth and measuring its various effects at the surface. The Schlumberger electrical logging method and various electric resistivity methods are using direct currents, whereas induction

Below—Recording truck of the type used for geophysical prospecting in the San Joaquin Valley, California. Right—300 lb. of dynamite shot in seismic survey.

Photo courtesy United Geophysical Co.

Photo courtesy Independent Exploration Co.

Above—Equipment used by seismograph crew in sandy beaches of south Texas islands. This crew operated so far from any base that the aeroplane was used to transport them to and from work daily.

methods are using alternating currents, and the Eltran method is concerned with the study of so-called transient currents.

The first electric methods were introduced into the United States around 1924 and have been used for oil exploration to some extent ever since. Their record is very moderate in the discovery of new fields prior to 1936 except by Schlumberger's electrical logging method. In 1936 the Eltran method appeared as one of the newest methods for finding favorable structures and stratigraphic conditions and perhaps as a direct detector of oil pools underground, and in 1937 five Eltran parties were engaged in exploration. Hawley wrote in 1938 that the use of transients in electrical prospecting helps to evaluate ". . . the presence of beds below the electrodes, the depth to a bed being proportional to the time after initiation at which the nick appears and to the resistivity of the region above the bed."

It is believed that about $3,000,000, excluding Schlumberger's electrical logging method and including $300,000 for the Eltran, has been spent on electrical prospecting for oil in the United States.

It is somewhat difficult to evaluate the contribution made by electrical methods to oil discovery. Unquestionably some credit is due to them for the discovery of oil credited to geophysics in general. The discovery of Oxnord field, California, in 1937, is credited to electric resistivity and magnetic methods.

Schlumberger's electrical logging method has a wide and well deserved reputation in the United States. In spite of the fact that millions of dollars were and are being spent by the American oil industry for information obtained by this electrical logging device, its great usefulness as a final check on oil possibilities and structures in a well drilled for oil is, perhaps, beyond evaluation.

SOIL ANALYSIS

Soil analysis methods are based upon the principle of detection of heavy hydrocarbons left in the soil as a result of slow leakage, through the ages, from the oil pools situated directly underground. Soil analysis methods of rather experimental nature were used in the United States for almost a decade, but since 1936, a few American scientific workers, after their preliminary work on a few already-discovered oilfields, began to stress the value of modern soil analysis as a discoverer of new oilfields. In 1937 three soil analysis parties were engaged in the United States in direct search for oil.

GEOTHERMAL

Geothermal prospecting is based upon the principles pertaining to the rate of flow of heat through formations and its relationship to favorable structural conditions. Geothermal prospecting was used for prospecting on a small scale for more than a decade. Nevertheless its contribution to the oil discoveries might be considered as negligible to the present time.

Van Ostrand wrote, "Geothermal prospecting is a possibility but as developed at present, it is much less efficient than other methods of geophysical prospecting."

RADIO-ACTIVE

The radioactive method is based on the presence of radioactive matter in rocks and formations and on certain affinity of oil to Rodon. Although the radioactive method has been used in the United States for more than a decade, it is still more or less of an experimental nature.

CONCLUSION

Assuming that the United States oil reserves were equal to 5,323,000,000 bbl. in 1925 (A.P.I.), 12,000,000,000 bbl. in 1932 (Garfias), 13,063,000,000 bbl. in 1936 (A.P.I), and 15,507,000,000 bbl. in 1937

Photo courtesy Schlumberger Well Surveying Corp.

Starting an electrode in the hole for a Schlumberger log.

(A.P.I.), and accepting Pratt's estimates pertaining to the major oilfields' discoveries resulting from geophysical exploration in the United States as equaling 9.3 percent for the years from 1926 to 1930 and 55.0 percent from 1931 to 1935, we obtain, by the law of averages 5,605,000,000 bbl. of oil were discovered prior to 1938 by the application of geophysical prospecting as follows: 781,000,000 bbl. in the period from 1926 to 1930, 1,930,000,000 bbl. from 1931 to 1935, and 2,894,000,000 bbl. in 1936 and 1937, assuming 60 percent oil discovery to the credit of geophysics in the last two years. Accepting $101,700,000 as the total sum spent on geophysical prospecting in the United States prior to 1938, we obtain the average cost of geophysical discovery equal to one and eight-tenths cents per barrel of oil. The total expenditure on geophysical prospecting is composed of the following items: (1) seismograph, $69,000,000; (2) torsion balance, $21,000,000; (3) magnetometer, $4,500,000; (4) gravimeter and pendulum, $3,400,000; (5) electric prospecting, excluding Schlumberger's electrical logging and including the Eltran method, $3,000,000; (6) soil analysis and others, $800,000.

The study of the data pertaining to the drilling of wildcat wells shows a marked increase in probabilities or chances of bringing oil wells in later years, especially on geophysically located structures. Increases in depth of drilling for oil structures from year to year can be partly attributed to the increase in exploration power in depth from year to year of some of the geophysical methods.

ACKNOWLEDGMENT

The writer acknowledges his debt to a few investigators for some data used in this article and whose names were only mentioned without giving references to their valuable publications in the bibliography. Also no mention is made of numerous scientific workers who made valuable contributions to the theory and practice of geophysical exploration because such mention is beyond the scope of the paper. Thanks are due to Dr. A. T. Braid, New York City, and to M. W. Boatman, of the New York Public Library, for his kind help in reading the manuscript. Also to the American Askania Corp.; Dr. H. B. Peacock of Geophysical Service, Inc. of Houston, Texas; Dr. S. J. Pirson of Pennsylvania State College, and Professor Dart Wantland of the Colorado School of Mines for the use of some of the photographs attached to this article.

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Radiometer in radio-active prospecting.

Terrace or flume method of evaporating salt water—the salt is one-half inch thick and will be covered as new furrows are thrown up adjacent to ones filled.

SALT WATER Flow in East Texas Taxes Ingenuity of Operators

By M. T. Pate

GROWING like shadows at sunset, the problem of disposing of the flood of salt water inevitably produced with crude in the East Texas field daily cuts the margin of profit for more operators in the field, and increases the extent of handling provisions.

As indicated by the latest available statistics, a total of over 4,500 wells are producing salt water in amounts sufficient to require treatment or disposal measures. This figure gives one out of every five wells now producing salt water; the production ranging from a few barrels per day in the more favorably situated wells to as high as 1,000 bbl. in the same time for other units.

Although only one in five wells is a salt water producer, considerably more than one-fifth the total East Texas field's area is confronted with the disposal problem, due to the fact that the more heavily drilled areas, such as Kilgore's town-site section, is not affected as much as are the marginal leases on the Western or water-drive side of the field.

Disposal of the salt water produced daily can no longer be effected simply by permitting the waste water to run to stream beds, there to find its way eventually to the Sabine river for final removal. Already, and despite the efforts of conservation forces, the water of the river is so saline as to be unpleasant to the taste, and to constitute a menace to stock growers farther down the valley. Only in time of flood may salt water legally be run to the river—unless in case of accidental failure of dams or other structures impounding the salt water.

Efforts to provide for salt water disposal to sands overlying the Woodbine have been unsuccessful, the rate of absorption being so slow as to require far too many wells for input service to be practical. Two attempts to carry away the waste in this manner have been made, with wells drilled to the overlying sands and high pressures being built up to force the saline waters into the sand.

Much of the East Texas field is overlain by a bed of fine grained sand and unconsolidated detritus, but attempts to dispose of the salt water through absorption in this medium quickly result in contamination of nearby surface water supplies, and eventual pollution of streams in the vicinity. Some slight infiltration is present when evaporation or storage ponds are first filled, but the salt crystallizes out and seals the pores in the earth rapidly, effectively stopping this method of disposal unless the ground in contact with the water is frequently broken up.

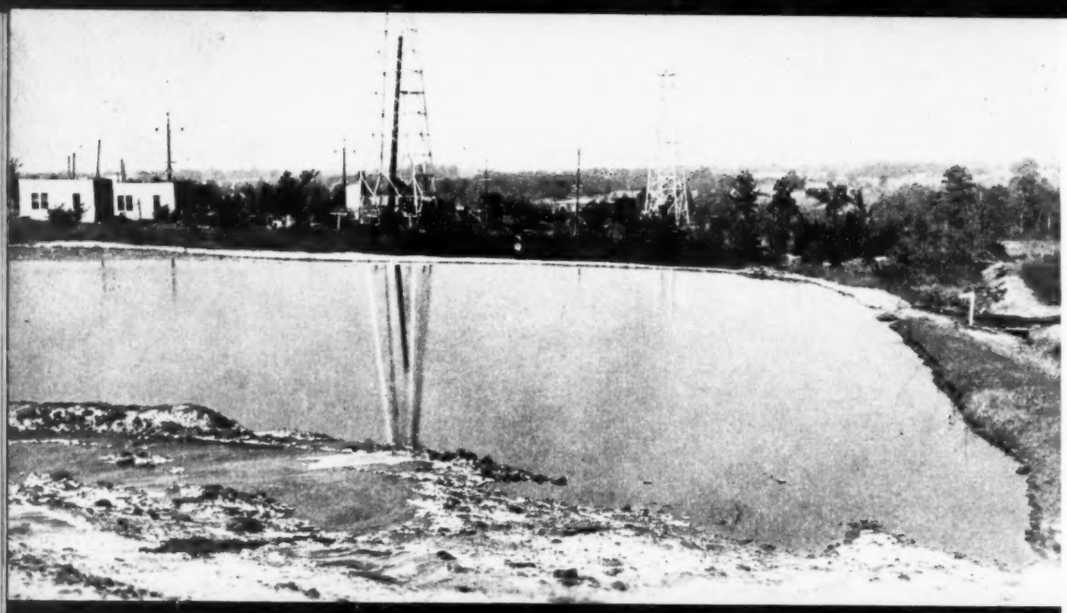
Evaporation is the method officially and ostensibly used by most producers, the ponds being of two types: the contour or shallow pools, in which as much area is presented to sun and wind as possible, with the water depth ranging from a few inches to perhaps two feet; and the storage pool, in which there is usually a thin section which can be cut—or which providentially fails—during wet weather when the streams are bankfull. The deep pools offer a method of saline concentration, some of the water testing a higher salinity than that of Great Salt Lake when sampled but two feet below the surface.

Since evaporation is greatly increased by the passing of hot, dry wind across the surface of the water, it is found advisable to carry the level as high as can be maintained without deliberately overflowing the dikes. On some of the leases sections of the dams are built of sand or sand and clay mixed, forming, in the vernacular of the lease men, "Hope-to-God" spots where, it is explained, they "'Hope-to-God' the dam breaks" and thus releases the stored up water, to permit reforming of the dam and impounding of a second store of water.

With the field producing over 100,000 bbl. of salt water daily (officially, with this figure probably 40 percent too low for actual flow) it is estimated that the storage pits now hold in excess of 20,000,000 bbl. of salt water—this figure being that covering the field at the end of an extended dry period when no release of impounded waters to the streams was possible.

To carry away this flood of water, improved evaporation methods are being devised. One lease, making upwards of 200 bbl. of salt water per day, actually runs less than one-fourth this amount to its pits, disposing of the remainder through spray systems which find but a mere trickle reaching the pools on a hot dry day. These spray systems require frequent renewal of piping, spray heads and, where required, pumps for handling the fluid. Where leases are situated on hillsides, as is often the case in the water flooded zone, natural flow is sufficient to assure pressure at the sprays, and replacement of materials for carrying the brine is the only cost.

When spray systems are used, provision must be made to control the drift of the corrosive vapors, as was proved by the fail-



One of the "Hope-to-God" pits in which the water laps the dike top, inviting a break and release of the impounding water.

Evaporation pit with quarter-acre area and capacity of 16,000 bbl., serving but one marginal well as salt water outlet.

ure of servicing derricks and tank battery structures on one lease lying down wind from one such spray system. The extent to which salt and salt water droplets may be carried by the wind can readily be determined by watching the grass and vegetation in the neighborhood of the pits. One company has set an arbitrary deadline of 300 ft. for the sprays, allowing no structures to be built nearer than that to the pits, and extending this figure to 600 ft. in the direction which is down wind to the prevailing breezes.

An innovation in salt water disposal has been worked out by one company which goes farther than simple evaporation methods. The saline fluid from the treating tanks is carried to a system of serpentine flumes or ditches winding back and forth across the face of sloping land on the lease, the contours of the ditches being laid out so as to permit brisk flow of the water through the ditch, yet restraining it sufficiently to prevent channelling or erosion.

As the salt water flows through these ditches it seeps into the earth forming the banks, and there is evaporated by combined effect of sun and wind, forming a saline deposit which in turn acts to take up more brine and facilitate its evaporation. When these ditches have been filled with salt and the banks covered with a half-inch or more of the white crusts, they are retrenched or re-terraced, new furrows being made paralleling the old ones, with the earth being turned over to bury the already deposited salt and thus prevent its being carried away by rains.

No use has been found for the brine produced with East Texas crude, save a rather restricted application of the more concentrated fluid pumped from the bottom of some pits and used to serve as binder for lease and third-class roads in the field. When so utilized, the salt binder is effective only as dust preventative during dry weather, the salt being dissolved out during wet weather and the surface washed away even more rapidly than plain or untreated materials. Many of the pools, where effective treating methods are used at the tank batteries, are filled with clear, blue water, with only an edging of white salt around the banks to betray its nature. This sign, ample warning to all oil-field children, fails sometimes to deter picnickers from swimming, only to have the first ones in likewise first out, as the water carries chemicals which affect tender skins much as does an astringent gas.

Left: Crude as it is, this spray on the end of the salt water disposal line at the pit edge accounts for nearly all the flow on hot, dry days.

Right: 10 ft. high, this dike helps form a 20 ft. deep pool as storage for the efflux from three wells. In clay soils like this, seepage or absorption is practically nil, and evaporation causes only loss of saline waters unless a dike fails.

Landowners who eventually will receive their holdings back are in many instances going to find the surface value of their property sadly depreciated. Vegetation is killed and the soil rendered sterile by comparatively small amounts of brine, as was demonstrated by the flow from one two-well tank battery, with a total salt water production per day of under 10 bbl. This amount was permitted to flow away, with a resulting five-acre desert in which nothing will grow.

Engineering studies indicate an eventual production of salt water in East Texas which will overtop the crude production. Should the field hold up to its present prorated limit of nearly 500,000 bbl. per day, this will indicate a like amount of salt water to be disposed of. To carry this ultimate (and theoretical) maximum flood of brine away from the field and dispose of it in the only available dumping spot two tentative programs have been worked out. The first calls for the laying of sufficient pipeline capacity and tying-in pumps enough to move this amount of brine per day. Apart from the first cost of this scheme is the probable high replacement cost, due to the rapidity with which the East Texas salt water in the presence of air acts to corrode metals.

The second plan would involve the securing of a more elaborate right-of-away than could the brine pipelines, in this case also looking toward handling the salt water to the Gulf Coast, there to pour the flood into the waters of the Gulf. To handle the projected amount a concrete canal, bitumen-lined, would be built to some designated point on the Gulf, taking advantage of the elevation of the East Texas field to provide the necessary flow to the Gulf. With an estimated cost of $75,000,000 to be taken up on salt water tariff, this canal would have to handle the estimated maximum flow for a period of three and one-third years to pay out at pipeline charges to the Gulf, assuming that all producers co-operated, and that gathering would be handled by individual producers.

As the salt water problem grows, producers find more and more reason to be thankful for proration, without which the field to-day would be a vast brine flat, with a wide band of wasteland down to the Gulf along the flood channel of the Sabine River. Under present conditions, there is time to study and plan before too great quantities of water must be handled.

Waste land created by salt water flow from two-well lease over a period of three years. At no time was salt stream equal to half-inch pipe capacity.

Pit covered by tarry deposits carried from the treating tank; the streak in foreground is where a rabbit floundered across the scummy surface—and lived.

U.T.P.S. Photo

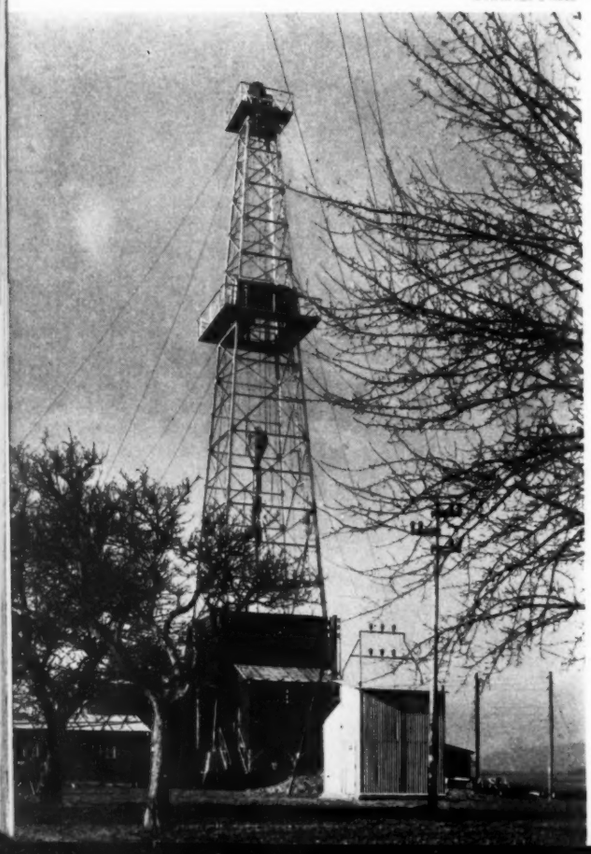
Above—Part of the main Pechelbronn oilfield with wells on the pump. Below—The modern rotary outfit purchased in the United States for testing at great depths.

PECHELBRONN France's Successful Oil Mining Enterprise

By Charles E. Chambers

Producing Crude Oil for Over Two Centuries, This Field Remains Only Proven Petrolific Area in France—Unrivaled for Application of Method—Deep Drilling and New Refinery Construction Contemplated.

U.T.P.S. Photo



PRODUCING a steady 500,000 bbl. of crude petroleum for the past few years, Pechelbronn remains France's only proven oilfield. It is not generally known that it is also one of the world's oldest oil producing areas, for a fairly constant output has been obtained for more than two centuries, and although modern improvements have been made from time to time the engineering principles involved are practically unchanged.

HISTORY

Pechelbronn owes its first prosperity to the old French family of Lebel, who exploited the heavy asphaltic oil oozing to the surface of their land from 1720 to 1870, selling it to neighboring peasants for greasing their heavy farm wagons. For 150 years, until the Germans took the Alsace region, the business prospered as a family affair—passing from father to son.

What may well be considered as the first authorization or grant by any government to search below the earth's surface for petroleum was granted in 1753 to the Lebel family. By that year seepage of oil ceased and a Royal decree signed by Louis XIV, King of France, was issued January 7th, 1753, giving them that right. A year later the same king ordered all royal coaches and wagons to use nothing but the grease from Pechelbronn, and he even went so far as to recommend its use to France in general as preferable to the imported animal fats, which were widely used at that time.

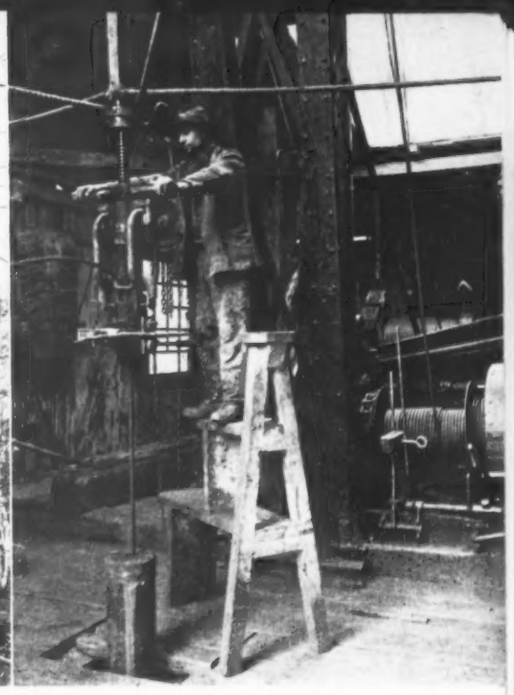
The early wells at Pechelbronn were little more than crude pits, from six to ten feet deep, having the same aspect and based on the same principle as the water wells in universal use. A large bucket would be lowered to oil level, and when full would be hoisted to the surface by block and tackle.

About 1753, the wells near the surface could no longer produce an adequate supply, forcing the owners to dig deeper, while the further down they sunk their shafts the lighter became the oil, which was then an undesirable feature. To overcome the difficulty of disposing of this useless light oil the first French refinery was developed—a plant as crude as the early pits. Large vats were placed on a fire, and the undesirable light constituents were distilled off and carried away by suitable vents, leaving only the concentrated grease which was so much in demand.

As the methods of extracting the oil from the ground and its concentration to grease were improved, the shafts were sunk deeper. By 1870 they had reached 1,000 ft. below the surface and had been galleried at different levels as are coal mines.

It was at this stage of development that Germany gained control of Alsace, and took over production of Pechelbronn oil. During the 48 yr. period in which the field was operated by Germans, the production was increased by modernizing existing facilities and in 1890 by installing a pump system. Germany has admitted that her marine offensive of the World War was made possible only by the lubricating material taken from Pechelbronn, for the product of these mines, while poor in gasoline, yields as much as 35 percent lubricating oil.

In 1918, Alsace again became a French Province. The government took over the land and soon formed the Société Anonyme d'Exploitation Miniers de Pechelbronn to exploit the Pechelbronn oil reserves. Soundings made in wells abandoned as dry showed that the suction pumps in use for 28 yr. had been able to remove only 30 percent of the oil. Operations were resumed, using miners and the same gallery system as before to obtain some of the remaining 70 percent by drainage.



Drilling rig and derrick of the type used for drilling wells down to the 4,000-foot level.

U.T.P.S. Photos

METHODS

It is a far cry from the Lebel family, who sold their crude product as axle grease for farm wagons, to the Pechelbronn of today. The present exploiting company markets its refined products for airplanes, automobiles, and everything that requires a first-class lubricant—yet, the same system is in use after 218 years; modernized to be sure, but still the same.

Modern oil production at Pechelbronn is initially by drilling and pumping oil wells similar to those in use in any other part of the world and secondary recovery is by mining. This system of secondary recovery has not been successfully adopted in any other country. Several years ago attempts were made to open a field for mining operations in Roumania, but these were forced to be abandoned due to connate water flooding the galleries to such an extent while under construction that pumps were unable to eject it fast enough to permit the miners to work.

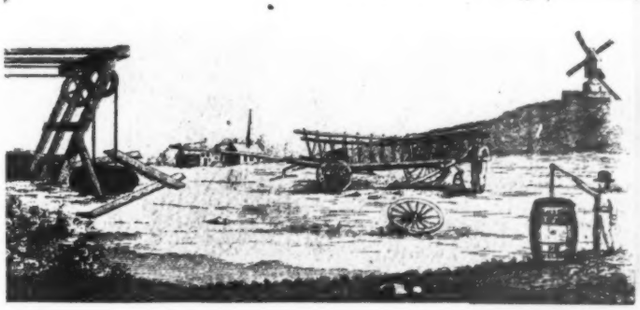
New oil pools are proven by drilling, and there are 38 rigs in constant operation in search of new oil-bearing areas in the Pechelbronn district. Up to the past few years the equipment used in this work has been of the percussion type, perfectly suitable for depths of 1,000 to 2,500 ft. When it became necessary to drill deeper holes, the Pennsylvania type rotary rig was introduced and has been in use for 12 years. This type has the power to get to the 4,000 ft. level and is just what is required for terrain of this sporadic character. Over 1,000,000 ft. of tests have been drilled to-date in search of new pools, of which there are several thousand, and the average aggregate annual depth since 1919 is more than 150,000 ft.

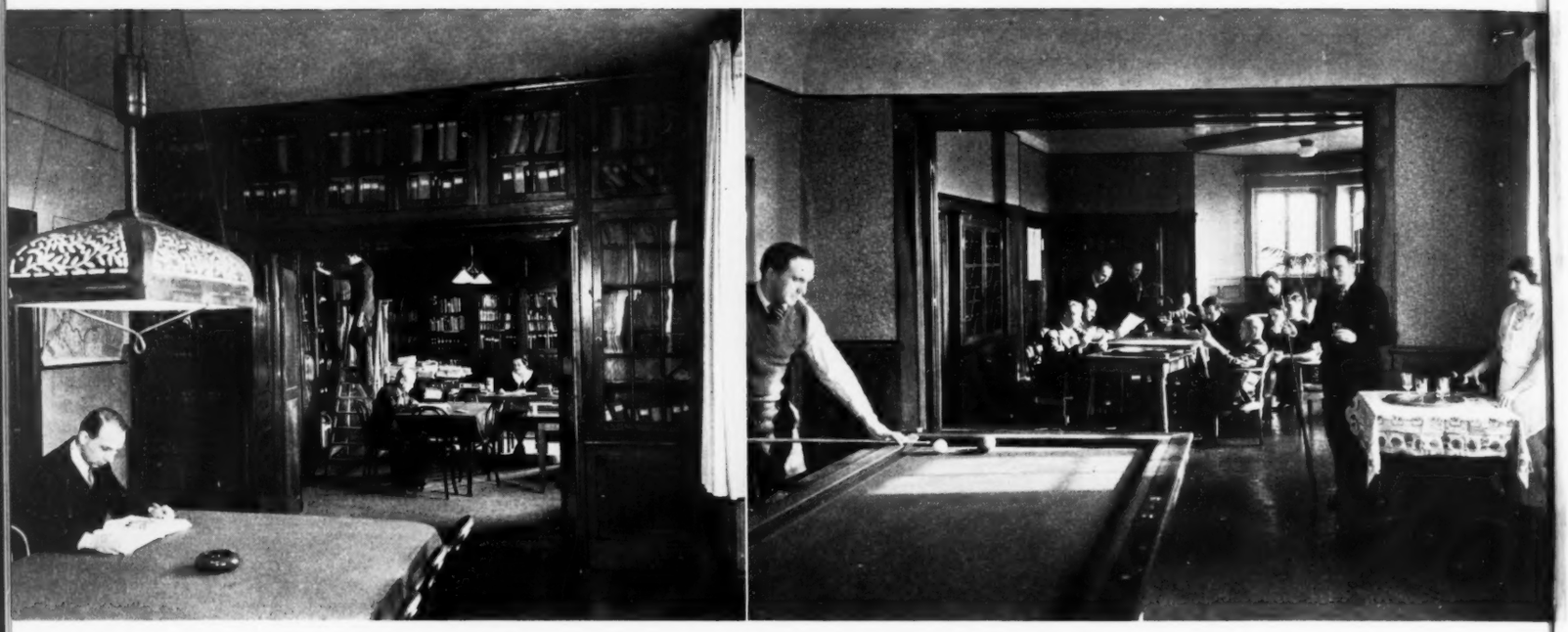
The findings of the test wells are submitted to the geological department of the company, which is in charge of the well until it is brought in. Upon obtaining production the well is turned over to the operating department for the duration of pumping, about seven years, when it is returned to the geological department to be galleried by the miners for further production.

A new mine is commenced when normal pumping methods fail to produce sufficient quantities of oil, and each mine consists of several shafts or pits. Each pit consists of a central shaft with numerous interconnecting galleries which serve to drain the surrounding oil-saturated strata. When tunnelling progresses beyond certain distances from the main shaft it is necessary to open a new entrance to the mine.

Early oil mine of the Lebel family (1770) and a modern mine entrance at Pechelbronn.

U.T.P.S. Photos





U.T.P.S. Photos *Left—Pechelbronn's library, which is famous in Europe for its literature on petroleum. Right—The company provides a club room and adequate recreational facilities for its employees.*

When starting a new entrance two pits must be made, one for the elevator and another to accommodate the ventilation system and compressed air tubes to the drills and pumps. With the exception of the miners' electric safety lamps, neither electricity nor explosives are permitted. The galleries are six by four feet, and are tracked to permit the removal of rock and sand to the shaft and the surface.

In prolonging the galleries a 12 ft. taper drill is used, which, if penetrating a gas pocket, is long enough to use as a temporary plug until a permanent seal is placed. When gas seepages occur unperceived, causing those in the vicinity to become intoxicated and sing, those affected are taken to the surface immediately. The dangers in these mines have been reduced to a minimum and the noxious and dangerous gas fumed are removed by a special system of ventilation.

Production in the mines is, as stated, by drainage. The galleries through the oil-saturated strata have central gutters which carry the oil drained by gravity to central draining pits, from there it is lifted by 650 compressed air pumps to the large surface tanks where the salt water is run off.

EXTENT

The Pechelbronn concessions amount to 100,000 acres of which 12,000 acres are being operated either as mines or as wells, with 75 mi. of gathering pipeline to the refinery in Merkwiller. There are three mines in operation covering four square miles—Lebel, Clemenceau, and Daniel Mieg—working at either the second or third levels of 800 to 1,500 ft. The galleries aggregate 150 mi. and are being prolonged at the rate of 60,000 ft. per year. A fourth mine in Pechelbronn was abandoned due to water-flooding. These mines are the only ones of their kind in the world.

There are 1,200 employees engaged in pumping operations at Pechelbronn and 1,100 mine workers, of which 83 percent are underground. To furnish recreation for the 3,000 employees of the field, mines, refinery and main offices, a large, modern club house has been erected with swimming pool, gymnasium, billiard room, and other facilities.

The offices of Société Anonyme d'Exploitation Miniers de Pechelbronn are large and ultra-modern, and include a library pertaining to the oil industry which is the largest and most complete in France. It is often called upon by European governments for data on the oil industry which cannot be obtained elsewhere, and three librarians are employed on research work and to keep adding material to this branch of the company.

FUTURE

Looking into the future, when wells must exceed the 4,000 ft. level, the company purchased in the United States during 1936 a rotary outfit with a 120 ft. derrick and 1,200 h.p. rotary engine; this outfit is designed for depths to 10,000 ft. and lifts 150 tons of tubing. The geological department is proud of this new rig, with which they hope to pass Europe's present record depth—11,092 ft., in Roumania.

The abandoned mine is to be rehabilitated for production; a freezing system is to be installed which, it is thought, will permit future operations. The plan is to freeze the flood water and keep it in that condition while working on the shafts and galleries.

The Merkwiller refinery is about to be abandoned. Plans are well advanced for the erection of a modern plant, capable of keeping step with the French demand for their products. At present Pechelbronn supplies one percent of the French consumption of gasoline (Socaline), 10 percent of the kerosene (Pen), five percent of the lubricating oil (Huiles Antar), 13 percent of the grease, 40 percent of the paraffin wax consumed, and three percent of the tar.

DEEP FORMATION TEST

On October 13th, 1938, a Johnston formation tester completed what is believed the world's deepest drill stem test in the Wasco area, Calif., (where the world's deepest well was drilled) at bout 13,000 ft. in seven inch casing. Two drill pipe leaks were discovered and repaired; the tester was rerun and the casing remained dry, assuring a successful test. It gave evidence of the production possibilities of the formation and proved that modern testing equipment can be used efficiently in the deepest wells.

THAMES HAVEN Storage Plant May Find New Uses

By Alec H. Day

Burgess Resignation Leaves London Guessing: Change in Thames Haven Oil Wharves Policy Indicated by Surprise Action.

RESIGNATION of T. C. J. Burgess, chairman and joint managing director of London and Thames Haven Oil Wharves Ltd., marks the opening of a new page in the company's recent stormy history.

Mr. Burgess, stated at the firm's last annual meeting that the undertaking had reached "what appeared to be the closing of one stage in our history and the beginning of a new one." These words have been fulfilled in a way not foreseen by Mr. Burgess.

Originally a profitable and useful storage undertaking, Thames Haven has largely changed its business within the past 20 yr. It now holds a controlling interest in Compagnie Industrielle Maritime, developing oil storage and port facilities at Le Havre, France, and has taken a leading part in the Irish National Refineries Ltd. project, designed to establish a refinery business in Dublin in opposition to the groups already established in the Irish market.

Both these new interests have proved troublesome to Thames Haven. The C.I.M., although successful enough in its development work, has so far not yielded profits on the scale expected, while by entering the Irish refining scheme, Thames Haven has not only alienated the goodwill of its largest customers, the National distributing companies in the British market, but has created serious financial problems for itself.

Formerly among the largest users of the Thames Haven storage plant, the Shell and Anglo-American companies naturally took umbrage at the entry of London and Thames Haven into the Irish refinery scheme, the success of which would tend to undermine their position in Southern Ireland. Shell has already terminated its storage contracts with the company, and with the raising of the tanker limit in the Thames estuary, Anglo-American contemplates utilizing its own storage at Purfleet and ignoring Thames Haven. Loss of business from these two concerns is serious to the Thames Haven undertaking.

Financial problems raised by the company's connection with Irish refining developments were made more serious by association with Parent Petroleum Interests Ltd. and with William Rhodes Davis. Parent Petroleum has been suggested as one of the potential sources from which crude was to be supplied for refining in Ireland, but Mr. Davis' activities in shipping stolen Mexican oil to Europe made it necessary for the Thames Haven company to sever its connection with him.

Opposition of the British authorities and of British public opinion to the handling of Mexican oil by British companies would have brought Thames Haven into general disfavor if the connection had been retained. The result was that the British shareholders in Parent Petroleum in June last paid £2,500,000 ($12,500,000) for Mr. Davis' holding in the company, other interests originally purchased from Mr. Davis, and represented by Crusader Petroleum Industries Ltd., being resold to him for £250,000 ($1,250,000).

The British interests concerned in these deals were Mr. Burgess, Lord Inverforth, another director of London and Thames Haven, and the Thames Haven company.

No details of the transactions have been made public, but since London and Thames Haven had already invested £1,180,121 ($5,900,605) in Parent Petroleum Interests, it may be taken for granted that it was intimately concerned in the new financial arrangements. Thames Haven's financial position, as revealed by the last balance sheet, was in no shape to bear any further burden. As recorded in WORLD PETROLEUM in August last, when the deal was discussed, there was a bank overdraft of £688,213 ($3,441,065) at December 31st, 1937, and a cash holding of only £13,434 ($67,170) compared with £694,975 ($3,474,875) two years previously.

Any tangible assets acquired as a result of the Davis deal in June cannot have provided suitable security for further bank accomodation, and the financing of Thames Haven during the current year has come to be regarded as a mystery by British oil men. It was reported some months ago that further bank finance would be difficult to obtain and finance may thus explain Mr. Burgess's hurried exit.

No information can be obtained as to the plans of the remaining directors, possibly because the negotiations on which those plans may be based are still in progress. In the absence of official news, many conjectures have been made as to the future of the company. One report suggested that the estrangement with the big distributing concerns would be ended and that these undertakings would again utilize Thames Haven storage as in the past.

There is no foundation for this suggestion, if only because of the fresh storage arrangements already made by the big oil groups. This does not imply that there is not a good prospect of Thames Haven storage plant being put to profitable use in the future. Current negotiations by the company suggest that it may be used for storage in connection with anti-aircraft defense schemes.

Mr. Burgess has generally been credited with being the prime mover in Thames Haven's connection with the Irish Refineries project and with Parent Petroleum interests. His resignation may therefore foreshadow a modification of policy on the part of the company in relation to these associations. Nevertheless, no announcment has been made regarding his other appointments, although he is believed to be also resigning as chairman and managing director of Compagnie Industrielle Maritime and chairman of C.I.M. Holdings, the holding company.

Mr. Burgess had been associated with London and Thames Haven for 36 yr., becoming secretary in 1902, and later participating in the management. He was appointed managing director in 1919, succeeding the late Lord Kylsant as chairman in 1931. Alfred C. Adams, the other managing director, has been appointed chairman, but this appointment is only a temporary one, and a fresh change is likely when the immediate future of the company has been settled.

A. E. Sawdy, the chartered accountant who has been associated with Parent Petroleum since its formation by Mr. Davis, has been appointed joint managing director of Thames Haven with Mr. Adams in Mr. Burgess' place.

A statement as to the present position and future policy of the company has been promised by the directors at a later date. Up to the present, the uncertainty created in the minds of shareholders by the Parent Petroleum share deal has not been cleared up by an official statement. The doubts thus raised must have been increased by the sudden retirement of Mr. Burgess from the management, and it is now due to the shareholders that the position should be clarified without undue delay.

Foreign Oil Legion

BRIAN M. GROVER, petroleum engineer recently with Anglo-Iranian Oil Company Ltd. at Masjid-i-Suleiman, southern Iran, was arrested November 20th when he attempted to take his wife out of Soviet Russia. He had hired a sports plane at Stockholm, Sweden, and flown 650 mi. before he was forced down because of fuel shortage some 100 mi. from Moscow. Mr. Grover had gone to help build up the Baku oil industry in 1932, and married a Russian girl, as did many overseas technicians of that period when they were received more cordially than they are now. In 1934 he left Russia for Iran. When he wanted to return he was unable to get permission from the Soviet authorities while his wife was unable to get an exit visa to join him. Having recently acquired a pilot's license, Mr. Grover decided to fly over the border to get her, for which he may be liable to imprisonment. Now that the Soviet is no longer in need of foreign exchange it no longer permits non-citizens to obtain exit visas for Russian wives on payment of $1,000, and many have had to leave their families.

JAN VAN SEVENTER, marine superintendent of Curacaosche Petroleum Industries Maatschapij, returned from New York to the Willemstad headquarters of Royal Dutch-Shell on board the SANTA PAULA, November 4th. Mr. and Mrs. van Seventer had just completed an enjoyable three-week visit to the United States and warmly recommended all European oil company officials in South America and the West Indies to take advantage of their vacations to tour North America. Their trip to the United States was by Pan American plane, taking 24 hr. from the Netherland West Indies, and Mr. van Seventer expressed his appreciation of the splendid service and of the courtesy shown by the airline staff.

Mr. and Mrs. van Seventer

W.P. Staff Photo

W.P. Staff Photo

Norbert Modriniak

DIPL. ING. NORBERT MODRINIAK, of the Department of Scientific and Industrial Research, Wellington, New Zealand, left New York for Texas where he will visit Houston and Tulsa. He is representing the Department to make a study of geophysical work in the United States—particularly seismic reflection and gravimeter. He made his departure from New Zealand October 17th and sailed to Los Angeles via Honolulu, after which he visited San Francisco and proceeded to Washington, D.C., and New York to gather further information in regard to geophysics. The Department of Scientific and Industrial Research has been requested to secure data for geophysical work on behalf of New Zealand Oil Concessions Ltd. of Christ Church, N.Z., which holds a 200 sq. mi. concession of the west coast of South Island.

Ella Barnett from Grace Line

Mr. and Mrs. Hurley

JAMES HURLEY, in the tax department of Standard Oil Company of N. J., returned to his home in Larchmont, N. Y., November 22nd after a 16 day cruise in Caribbean waters on board the Grace liner SANTA PAULA. Accompanied by Mrs. Hurley, he was taking advantage of his vacation to visit South America and the West Indies for the first time, calling at Curacao, Venezuela, Colombia, Jamaica and Haiti.

R. H. EBBETS, accompanied by Mrs. Ebbets and their two children, Marion and Charles, left their Lake Mohawk, N.Y., home and sailed on the SANTA LUCIA November 5th for South America. Mr. Ebbets is general superintendent for International Petroleum Company at Negritos, near Talara, Peru.

WILLIAM BLACKWELL, A.M.I.P., director of The W. Blackwell Oil Company, has been elected president of the National Lubricating Oil and Grease Federation, England. He has been engaged in the British oil trade for over 30 yr., following in his father's footsteps, as W. Blackwell was president from 1934 to 1935. For ten years he has been a member of the Birmingham City Council, and taken a lively interest in civic affairs. Politics brought him into close contact with the late SIR AUSTEN CHAMBERLAIN, K.G., M.P., on whose platform he frequently spoke. Being progressive, there is no small possibility that Mr. Blackwell's period of office will see the Federation raised in status by becoming part of an important national lubricating trade association.

Reese H. Taylor, Los Angeles steel man and Union Oil Company director, who is Union's new president.

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Paul Ehrhardt and M. **Bertaux**, of Soc. Anon. d'Exploitacion de Miniers de Pechelbronn, arrived in New York on board the **Normandie** November 10th for a business trip in connection with the company's oil mining industry in France. The existing refinery at Merkwiller, in Alsace, is to be replaced by a modern plant designed to meet France's consumption requirements.

Dr. H. **Hepworth** and R. S. **Horsefall**, of Imperial Chemical Industries Ltd., sailed for England November 12th, on board the **Normandie**. I.C.I. is the concern operating a large coal hydrogenation plant at Billingham-on-Tees for the manufacture of synthetic gasoline.

Alfred Meyer, of Caracas Petroleum Corporation, sailed from New York en route to Europe on board the liner **Normandie**, November 12th.

F. H. **Henry**, executive of Socony-Vacuum Oil Company and Compagnie Industrielle des Pétroles S.A., returned to New York on board the **Normandie** November 24th after an extensive business trip to Europe and the Near East. Mr. Henry, who is in charge of Socony-Vacuum's Near Eastern activities, had left New York for the Continent September 6th, arriving in time for the Czecho-German crisis and the resulting war scare. Mr. Henry then took a boat to Alexandria, Egypt, and flew by plane to Palestine—where skirmishes between the Arabs and Jews were of almost daily occurrence and the traveler is in danger of injury from road mines and stray bullets. From Palestine he proceeded to Syria and thence to France and England, returning to New York just in time to have Thanksgiving dinner with his family.

© Boyé

Rodney S. Durkee, formerly comptroller of Socony-Vacuum, who has been appointed vice-president and general manager of Lane Wells.

C. B. **de Bruyn**, president of Shell Chemical Company of California, arrived in New York on board the liner **Nieuw Amsterdam** November 5th, en route to California from a trip to The Hague.

A. **Waterson** and J. L. N. **Pollock** have been elected directors of Anglo-American Oil Company Ltd. Both will continue to develop sales throughout Great Britain and Northern Ireland.

Mr. Waterson joined Anglo-American in May, 1914, but a few months later joined the Royal Army Service Corps, later transferring to the Artillery. After the war he became circuit manager in the Edinburgh district and in 1929 was appointed Anglo-American's first marketing specialist. He joined the head office staff in 1931 and was made a general sales manager in 1934.

Mr. Pollock joined Anglo-American in 1919 and was in the first cadet training class the company formed and received ample training in all its activities. In 1924 he was promoted to branch manager at Middlesbrough, later at Hull. In 1931 he assumed control of the eastern counties division as sales manager. 1936 saw him moved to headquarters as assistant general manager, and after study of other European markets he became a general sales manager.

Elbert E. **Boylan**, vice-president of Caracas Petroleum Company, accompanied by his wife and son Michael, sailed from New York on the **Santa Paula** November 4th for Caracas, Venezuela.

Denies A. C. **Dallaston** and Mrs. Virginia Dallaston arrived in New York on board the **Santa Barbara** November 7th, en route from Guayaquil, Ecuador. Mr. Dallaston is connected with Ecuador Oilfields Ltd. as superintendent of stores.

W.P. Staff Photo

F. H. Henry in his office at 26 Broadway.

WORLD OIL

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specified

U. S. BARRELS

	November 1937	December 1937	January 1938	February 1938	March 1938	April 1938	May 1938	June 1938	July 1938	August 1938	Sept. 1938	Preliminary Figures Oct. 1938
United States	104,206,000	106,579,000	106,007,000	94,662,000	106,524,000	102,702,000	98,674,000	94,277,000	102,898,000	106,165,000	98,661,000	**106,100,000**
Soviet Union[4]	16,923,000	17,600,000	17,647,000	13,591,000	15,984,000	17,850,000	17,580,000	18,540,000	18,200,000	18,000,000	18,200,000	**18,000,000**
Venezuela	17,044,016	17,096,298	15,271,902	13,792,479	15,109,040	13,696,219	15,994,400	16,302,150	14,912,555	16,616,673	16,271,096	**17,352,171**
Iran[5]	6,821,616	5,999,642	5,907,458	6,414,470	8,284,215	7,090,486	6,975,256	5,792,228	5,338,990	5,861,366	5,676,998	**5,860,000**
Netherland India: Sumatra	4,626,395	4,671,582	2,674,572	2,587,988	2,912,764	2,809,415	2,971,443	2,893,856	2,814,237	2,901,321	2,917,167	**3,049,196**
Borneo			1,123,800	1,008,290	1,114,431	1,056,224	1,066,281	1,013,163	1,061,980	970,690	1,069,872	**1,123,102**
Java[9]			637,102	590,763	643,568	639,582	674,927	616,845	585,086	524,384	482,417	**523,623**
Ceram			53,215	48,388	50,377	52,329	51,524	49,870	54,035	54,825	50,355	**50,444**
Roumania	4 162,000	4,198,000	4,099,000	3,751,692	4,182,000	4,090,000	4,169,000	4,015,000	4,115,000	4,075,736	3,915,029	**4,028,750**
Mexico	4,211,293	4,349,415	4,141,977	4,016,000*	1,226,368*	1,912,493*	2,301,995*	2,374,815*	2,000,000[1]	2,300,000[1]	3,250,000[1]	**3,500,000**
Iraq	2,645,099	2,431,532	2,670,844	2,385,464	2,717,278	2,592,996	2,332,746	2,653,579	2,806,903	2,829,528	2,621,547	**2,431,949**
Colombia	1,797,625	1,824,956	1,784,638	1,508,487	1,841,882	1,642,195	1,819,689	1,826,136	1,826,848	1,870,013	1,797,158	**1,868,631**
Trinidad	1,300,485	1,349,908	1,378,021	1,304,819	1,438,436	1,418,825	1,481,285	1,431,476	1,500,171	1,505,959	1,514,893	**1,594,480**
Argentina[1]	1,365,000	1,370,000	1,378,000	1,289,000	1,380,000	1,349,000	1,382,000	1,346,000	1,349,000	1,360,000	1,358,000	**1,360,000**
Peru[3]	1,428,079	1,486,121	1,365,152	1,224,437	1,474,364	1,296,090	1,343,259	1,303,536	1,335,623	1,328,143	1,280,691	**1,331,111**
Bahrein[6]	749,354	805,236	805,800	707,379	737,164	692,403	620,746	661,602	699,176	713,149	714,349	**708,962**
Burma[7]	631,584	640,195	616,522	496,306	633,644	635,903	667,346	679,368	638,000[1]	635,000[1]	650,000[1]	**635,000**
Brunei[8]	376,487	405,623	409,592	381,052	445,194	428,829	445,505	425,184	453,393	448,219	478,080	**477,459**
Canada[2]	341,517	408,580	457,408	413,158	480,803	464,316	566,086	537,654	693,332	817,706	886,111	**900,000**
Great Germany: Old Reich[14]	272 665	277,551	268,028	257,967	355,684	342,387	329,688	326,842	346,435	342,484	328,098	**342,000**
Ostmark[15]	18,620	20,850	25,620	28,160	30,070	29,100	32,845	30,000[1]	29,000[1]	31,000[1]	29,000[1]	**30,000**
Poland	318,360	325,940	318,928	293,232	327,077	315,768	324,803	315,381	314,000[1]	328,115	327,000[1]	**318,000**
Japan[10]	214,330	211,436	218,594	214,191	214,820	207,522	216,078	216,707	216,707	217,525	170,597	**217,000**
Ecuador	176,252	178,776	187,525	171,138	191,746	181,331	190,542	188,712	192,360	193,634	189,037	**192,702**
British India[11]	197,043	210,360	196,697	132,164	197,792	196,543	198,872	192,656	195,000[1]	200,000[1]	197,800[1]	**195,000**
Sarawak[12]	126,439	131,901	137,497	126,578	137,281	133,248	137,824	132,240	132,007	107,102	123,476	**223,165**
Egypt[13]	95,082	94,509	91,927	84,974	94,545	88,555	89,935	84,998	83,412	143,978	157,533	**208,377**
Albania[16]	No Date	No Date	42,400	39,200	42,400	41,000	42,400	72,300	46,049	4,998	68,655	**48,000**
France	42,639	42,368	41,560	40,840	43,589	42,839	48,545	43,189	43,574	43,000[1]	42,000[1]	**43,000**
Hungary	1,930	11,980	13,744	12,461	13,976	13,775	18,691	26,018	25,888	30,900[1]	41,000[1]	**49,800**
Czechoslovakia	12,297	11,734	11,070	10,437	12,158	10,731	10,960	10,159	9,333	11,015	10,933	**11,000**
Bolivia	11,751	12,810	10,302	7,128	9,100	8,800	9,000	8,790	9,500	9,200[1]	8,500[1]	**8,800**
Italy	8,565	8,493	9,048	7,969	9,612	9,459	9,563	8,646	9,378	9,057	8,267	**7,000**
Other Countries[17]	5,800	6,000	6,000	5,400	6,000	5,800	6,000	5,800	6,000	6,000	50,000	**50,000**
WORLD TOTAL	170,131,323	172,760,796	170,007,943	151,605,011	168,895,378	164,046,163	162,783,229	158,401,890	168,947,206	170,655,720	163,546,659	**172,838,722**

[1] Estimate.
[2] Includes natural gasoline production.
[3] International Petroleum Company and Lobitos Oilfields Ltd. figures combined.
[4] Russian Sakhalin included with U.S.S.R.
[5] Anglo-Iranian Oil Company Ltd. figures revised—fuel oil returned to the ground has been deducted.
[6] Bahrein Petroleum Company Ltd. figures.
[7] Does not include Assam or Punjab, which are listed together under British India.
[8] British Malayan Petroleum Company Ltd. figures.
[9] Includes Madura.

Official Crude Oil Production Figures for 1932 to 1937 (Revised)

	Daily Av. Jan.-Oct. 1938	Daily Av. Jan.-Oct. 1937	Total Jan.-Oct. 1938	Total Jan.-Oct. 1937	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	**3,344,309**	3,514,392	**1,016,670,000**	1,068,375,000	1,279,160,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Soviet Union	**571,026**	550,440	**173,592,000**	167,333,661	201,856,661‡	199,635,921	184,008,033	175,635,783	155,596,429	155,927,997
Venezuela	**510,917**	505,050	**155,318,685**	153,535,163	187,675,477	155,270,840	148,809,057	136,098,681	117,113,940	115,615,782
Iran	**207,900**	214,598	**63,201,467**	65,237,743	78,109,001	62,977,950	57,520,488	57,902,092	54,440,075	49,516,697
Netherland India: Sumatra	**93,855**	144,092	**28,531,959**	44,803,973	33,451,511	30,469,428	28,004,595	26,336,011	22,345,172	18,570,928
Borneo	**34,894**		**10,607,833**		12,960,072	13,068,910	13,529,185	14,335,543	15,003,175	15,228,615
Java	**19,468**		**5,918,297**		7,152,931	3,618,293	3,462,440	3,778,920	3,600,816	3,837,142
Ceram	**1,695**		**515,362**		537,436	375,823	311,872	273,698	285,335	309,957
Roumania	**133,349**	144,854	**40,538,131**	44,035,725	52,395,725	63,532,846	61,270,072	61,849,306	53,919,708	53,651,978
Mexico	**88,893**	124,654	**27,023,648**	37,894,979	46,455,687‡	41,027,915	40,240,563	38,171,946	34,000,830	32,805,496
Iraq	**85,667**	83,970	**26,042,834**	25,527,029	30,603,660‡	29,913,150	27,410,983	7,639,849	1,094,915	871,840
Colombia	**58,505**	54,523	**17,785,677**	16,674,962	20,297,543‡	18,756,110	17,597,655	17,337,900	13,156,126	16,415,214
Trinidad	**47,922**	42,278	**14,568,365**	12,852,596	15,502,989	13,237,030	11,671,224	10,894,363	9,561,353	10,126,121
Argentina	**44,579**	44,802	**13,551,000**	13,619,717	16,354,717	15,457,960	14,297,025	14,021,901	13,690,556	13,138,747
Peru	**43,692**	47,845	**13,282,406**	14,544,912	17,459,112	17,593,069	17,056,555	16,314,381	13,257,318	9,899,265
Bahrein	**23,226**	20,420	**7,060,730**	6,207,674	7,762,264	4,644,635	1,264,807	285,072	31,377	902
Burma	**20,681**	21,631	**6,287,089**	6,575,774	7,847,553	7,587,718	7,181,113	7,278,859	7,114,311	7,073,437
Brunei	**14,449**	11,891	**4,392,507**	3,614,928	4,397,038	3,296,938	3,302,905	2,705,350	2,035,656	1,200,026
Canada	**20,449**	7,384	**6,216,574**	2,244,928	2,995,025	1,507,931	1,447,204	1,410,895	1,145,333	1,044,412
Great Germany: Old Reich	**10,656**	10,191	**3,239,613**	3,098,084	3,148,300	3,076,858	2,967,438	2,204,402	1,656,602	1,594,807
Ostmark	**969**	598	**294,795**	181,796	221,266	50,092	44,347	27,965	5,765	804
Poland	**10,468**	10,801	**3,182,304**	3,155,562	3,799,862	3,869,575	3,901,881	4,011,336	4,174,079	4,219,634
Japan	**6,940**	6,783	**2,109,741**	2,062,075	2,487,841	2,403,072	2,294,878	1,872,837	1,504,412	1,683,439
Ecuador	**6,180**	5,942	**1,878,727**	1,806,408	2,161,436	1,942,467	1,731,785	1,636,619	1,619,902	1,597,641
British India	**7,258**	5,770	**1,902,524**	1,754,250	2,161,653	1,978,329	2,037,810	1,921,863	1,628,803	1,743,878
Sarawak	**4,574**	4,616	**1,390,418**	1,403,225	1,655,565	1,547,882	1,776,593	1,942,591	2,206,815	2,329,733
Egypt	**3,711**	3,203	**1,128,234**	973,676	1,163,267	1,262,666	1,255,151	1,527,252	1,653,535	1,071,976
Albania	**1,472**	1,900	**447,402**	273,527	591,677‡	219,693	41,218	17,500	11,437	9,212
France	**1,421**	1,385	**432,136**	422,060	507,067	534,063	529,664	700,000	786,366	755,146
Hungary	**810**	Nil	**246,253**	Nil	13,910	100	Nil	Nil	Nil	Nil
Czechoslovakia	**354**	325	**107,796**	98,759	122,790	126,603	136,580	177,797	121,695	126,603
Bolivia	**293**	324	**89,120**	98,562	123,123	104,746	163,295	157,875	111,973	41,907
Italy	**290**	322	**87,999**	97,743	115,801‡	129,653	128,615	162,449	213,534	242,563
Other Countries	**483**	192	**147,000**	58,200	70,000	37,100	32,300	64,000	54,100	73,300
WORLD TOTAL	**5,421,355**	5,585,176	**1,647,788,626**	1,698,562,691	2,039,810,062	1,797,871,366	1,652,023,331	1,516,760,036	1,438,797,443	1,305,574,242

‡Preliminary.

PRODUCTION

Figures in U. S. barrels of 42 gal.—Conversion ratios used are weighted averages for individual countries

METRIC TONS

	Nov. 1937	Dec. 1937	Jan. 1938	Feb. 1938	March 1938	Apr. 1938	May 1938	June 1938	July 1938	Aug. 1938	Sept. 1938	Preliminary Figures Oct. 1938
United States	14,106,674	14,427,914	14,345,022	12,814,670	14,420,469	12,916,610	13,357,804	12,762,583	13,939,606	14,507,243	13,189,481	**14,500,000**
Soivet Union[4]	2,320,000	2,410,000	2,421,000	2,440,000	2,192,000	2,448,000	2,411,000	2,543,000	2,497,000	2,470,000	2,497,000	**2,470,000**
Venezuela	2,518,696	2,526,422	2,256,820	2,038,197	2,232,753	2,023,972	2,363,588	2,409,066	2,205,195	2,455,545	2,404,477	**2,564,234**
Iran[5]	902,208	793,496	781,304	847,525	1,095,647	937,768	922,528	766,064	706,120	775,208	750,824	**760,000**
Netherland India: Sumatra	620,994	627,058	359,003	347,381	390,975	378,445	398,988	388,437	377,750	389,439	391,566	**409,288**
Borneo			150,847	135,341	149,588	141,775	143,124	135,995	142,549	130,294	143,607	**150,752**
Java[9]			85,517	79,297	86,385	85,850	90,460	82,798	78,535	70,387	64,754	**70,285**
Ceram			7,143	6,495	6,762	7,024	6,916	6,694	7,253	7,359	6,759	**6,771**
Roumania	570,137	575,068	559,973	512,175	570,239	558,362	568,874	548,139	561,775	556,415	534,475	**550,000**
Mexico	625,192	647,196	614,902	596,200*	182,061*	283,921*	341,745*	352,555*	297,000[1]	355,000[1]	482,500[1]	**519,600**
Iraq	354,666	326,030	358,118	319,853	364,344	347,948	312,771	355,803	376,415	379,395	351,508	**326,086**
Colombia	250,540	254,349	248,730	210,242	256,700	228,878	253,615	254,514	254,669	260,629	250,475	**260,436**
Trinidad	183,012	189,967	193,923	183,622	202,425	199,666	208,456	201,446	211,113	211,928	213,185	**224,385**
Argentina[1]	194,000	195,000	196,300	183,600	198,000	192,200	196,900	191,900	192,200	193,800	193,500	**194,000**
Peru[3]	189,250	196,942	180,911	162,263	195,383	171,759	178,010	172,745	168,725	176,006	167,718	**177,893**
Bahrein[6]	102,539	110,186	109,751	95,450	100,478	94,457	84,723	90,435	95,428	97,279	97,479	**96,660**
Burma[7]	87,199	88,388	85,120	69,240	91,765	87,796	92,275	93,797	87,900[1]	87,800[1]	89,100[1]	**87,800**
Brunei[8]	49,500	53,110	54,623	49,965	58,376	56,230	58,416	55,552	59,464	58,772	62,688	**62,607**
Canada[2]	43,143	51,614	57,783	52,193	60,739	58,649	71,511	67,934	87,586	103,298	111,686	**118,000**
Great Germany: Old Reich[14]	39,272	39,977	38,604	37,155	51,517	49,314	47,485	47,075	49,897	45,007	47,256	**45,000**
Ostmark[15]	2,570	2,850	5,816	5,253	5,820	5,697	4,900	5,800[1]	5,600[1]	5,850[1]	5,600[1]	**5,800**
Poland	42,000	43,000	42,075	38,685	43,150	41,658	42,850	41,607	41,000[1]	43,287	43,000[1]	**42,000**
Japan[10]	30,502	30,089	30,070	30,481	30,586	29,518	30,750	30,839	30,839	30,955	24,977	**31,000**
Ecuador	24,965	25,377	26,577	24,254	27,175	25,699	27,004	26,743	27,262	27,412	26,791	**27,310**
British India[11]	27,205	29,040	27,157	18,247	27,308	27,136	27,357	26,599	27,000[1]	27,600[1]	27,300[1]	**27,000**
Sarawak[12]	16,580	17,270	18,337	16,597	18,001	17,472	18,072	17,340	17,309	13,913	16,191	**16,150**
Egypt[13]	13,593	13,511	13,365	12,005	13,516	12,660	12,642	12,151	11,924	20,583	22,521	**29,789**
Albania[16]	No data	No data	6,200	5,650	6,200	6,060	6,200	10,790	6,873	746	10,247	**7,000**
France	5,971	5,933	5,820	5,579	6,104	5,999	6,798	6,048	6,102	6,000[1]	5,900[1]	**6,000**
Hungary	250	1,550	1,778	1,612	1,808	1,782	2,418	3,366	3,349	4,000[1]	5,300[1]	**6,400**
Czechoslovakia	1,786	1,714	1,617	1,526	1,776	1,566	1,601	1,484	1,521	1,609	1,597	**1,600**
Bolivia	1,478	1,611	1,295	897	1,140[1]	1,110[1]	1,130[1]	1,100[1]	1,200[1]	1,160[1]	1,000[1]	**1 100**
Italy	1,064	1,055	1,124	990	1,194	1,175	1,188	1,074	1,164	1,125	1,027	**1,000**
Other Countries[17]	800	900	850	770	850	830	850	830	850	850	7,000	**7,000**
WORLD TOTAL	23,325,786	23,686,607	23,287,465	21,343,412	23,091,236	21,441,232	22,292,949	21,512,303	22,568,173	23,515,894	22,247,789	**23,802,946**

[10] Japanese Sakhalin, Taiwan (Formosa) and Hokkaido included with Japan.
[11] Excluding Burma.
[12] Sarawak Oilfields Ltd. figures.
[13] Anglo-Egyptian Oilfields Ltd. figures.
[14] Prussia, Thuringia and Baden.
[15] Formerly known as Austria.
[16] Italian imports of Albanian crude oil.
[17] Nominal figure representing proportion to world total represented by: Morocco, Cuba, New Zealand, Barbados, Greece, Algeria, Yugoslavia, Australia, Great Britain, Arabia and China.
* Official Figures—Petroleos Mexicanos.

Official Crude Oil Production Figures for 1932 to 1937 (Revised)

	Daily Av. Jan.-Oct. 1938	Daily Av. Jan.-Oct. 1937	Total Jan.-Oct. 1938	Total Jan.-Oct. 1937	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	**449,847**	474,632	**136,753,488**	144,288,209	172,822,797	148,707,864	134,912,143	122,913,903	122,601,191	106,289,292
Soviet Union	**80,227**	76,108	**24,389,000**	23,137,025	27,867,025‡	27,384,900	25,241,100	24,092,700	21,330,100	21,389,300
Venezuela	**75,506**	74,634	**22,953,847**	22,688,808	27,733,926	22,945,299	21,990,373	20,112,115	17,293,193	17,085,334
Iran	**27,444**	28,404	**8,342,988**	8,634,776	10,330,480	8,329,293	7,607,500	7,657,971	7,200,093	6,548,941
Netherland India: Sumatra	**12,602**	19,783	**3,831,272**	6,013,956	4,490,137	4,114,710	3,759,006	3,535,035	2,999,352	2,492,742
Borneo	**4,684**		**1,423,872**		1,739,607	1,773,545	1,815,998	1,924,234	2,013,849	2,043,707
Java	**2,613**		**794,268**		960,125	499,097	464,757	510,320	483,331	515,187
Ceram	**227**		**69,176**		72,139	50,446	41,862	36,738	38,300	41,605
Roumania	**18,205**	19,762	**5,534,216**	6,007,795	7,153,000	8,704,000	8,394,000	8,473,355	7,387,000	7,350,321
Mexico	**13,242**	18,501	**4,025,484**	5,624,269	6,896,657‡	6,090,842	5,973,955	5,666,857	5,049,109	4,870,175
Iraq	**11,488**	11,334	**3,492,241**	3,445,489	4,126,185‡	4,079,066	3,724,231	1,048,108	147,943	118,887
Colombia	**8,154**	7,695	**2,478,888**	2,339,362	2,844,251‡	2,614,092	2,452,635	2,416,432	1,833,606	2,287,835
Trinidad	**6,744**	5,950	**2,050,149**	1,808,697	2,181,676	1,862,796	1,642,446	1,533,122	1,345,532	1,425,009
Argentina	**6,356**	6,385	**1,932,400**	1,941,063	2,330,063	2,202,304	2,036,903	1,997,706	1,950,499	1,871,882
Peru	**5,761**	6,340	**1,751,413**	1,927,499	2,313,691	2,331,454	2,260,903	2,161,990	1,756,867	1,311,856
Bahrein	**3,165**	2,782	**962,140**	845,832	1,058,557	635,555	173,072	39,008	4,293	123
Burma	**2,870**	2,986	**872,593**	907,804	1,083,391	1,047,593	991,456	1,004,951	982,233	976,589
Brunei	**1,897**	1,559	**576,693**	473,935	576,545	470,991	471,842	386,478	290,808	171,432
Canada	**2,597**	933	**789,379**	283,673	378,430	190,495	182,820	178,233	144,686	131,937
Great Germany: Old Reich	**1,507**	1,231	**458,310**	374,202	453,451	444,600	427,400	317,500	238,600	229,700
Ostmark	**184**	91	**56,066**	27,590	33,010	7,473	6,616	4,172	860	120
Poland	**1,380**	1,369	**419,312**	416,301	501,301	510,630	514,760	529,200	550,670	556,680
Japan	**988**	965	**299,315**	293,449	354,040	341,976	326,580	266,520	212,667	239,567
Ecuador	**875**	842	**266,227**	255,984	306,326	275,293	245,434	231,947	229,578	226,423
British India	**864**	796	**262,704**	242,205	298,450	273,137	281,072	265,341	224,879	240,767
Sarawak	**557**	602	**169,382**	183,235	217,085	221,126	253,799	277,513	315,259	332,819
Egypt	**530**	458	**161,156**	139,194	166,298	177,491	176,436	214,671	232,437	265,055
Albania	**217**	145	**66,092**	44,000	88,310	32,760	6,152	2,500	1,707	1,375
France	**195**	194	**59,350**	59,104	71,008	74,788	74,172	98,025	110,120	105,758
Hungary	**105**	40	**31,813**	12,110	13,910	13	Nil	Nil	Nil	Nil
Czechoslovakia	**52**	48	**15,897**	14,436	17,936	18,665	19,946	25,971	17,776	18,493
Bolivia	**36**	41	**11,132**	12,398	15,487	13,197	20,540	19,858	14,085	5,284
Italy	**36**	40	**11,061**	12,208	14,261	16,106	15,977	20,180	25,526	27,046
Other Countries	**68**	27	**20,680**	8,300	10,000	5,300	4,600	9,100	7,700	10,500
WORLD TOTAL	**741,223**	764,677	**225,332,004**	232,462,908	279,533,130	240,536,897	226,410 486	207,970,754	197,024,849	179,181,741

‡Preliminary total

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Petroleum Industry. Edited by Dr. O. W. Willcox

MAP

Geological Map of California—Prepared in 1938 by Olaf P. Jenkins, Chief Geologist, and published by Division of Mines, CALIFORNIA DEPARTMENT OF NATURAL RESOURCES, Walter W. Bradley, Chief Mineralogist; Ferry Building, San Francisco, $4.00.

This new geological map of California is issued in six sheets, each 30 by 36 in. on a scale of 1:500,000. It is a revision of the 1931 map, with much new information drawn from all available sources, published and unpublished. Besides showing all the known formations, from the most ancient to the most recent, a special section shows the eleven geomorphic provinces of the state, and other sections show the distribution of mineral products. It is a fine piece of work which every person interested in California's geology will wish to have.

GEOLOGY

Applications of Some Spectroscopic Methods to Problems of Petroleum Geology and Engineering—Eldon A. Means, in PETROLEUM ENGINEER, vol. 9 (1938), No. 13, pp. 37-38; 40.

The use of X-ray spectroscopic methods in the study of minerals has long been known, and it now appears possible to apply them to problems of the oilfields. The advantage of these methods consists in the certainty with which a mineral or an element or a crystal form in a rock sample can be identified, and thus the method becomes of use to the petroleum geologist in following tracer elements, that is, elements peculiar to certain formations.

It has been found that in general six minerals describe the constituents of an average drill sample. If these minerals are designated as A, B, C, D, E, and F, we can compile the accompanying table.

Formation	Pattern
Fort Riley lime	ECA
Florence Flint	ACE
Neva lime	BA
Americus	BAXC
Howard	BAD
Topeka	BAC
Mississippi	ACD or ABD
Viola Simpson	B, BC, or CB
Arbuckle	AC or CA

These are representative patterns chosen from several wells in Kansas. Most of these wells are in the central part of the state. The data thus accumulated were applied to a well in the western part of the state for the purpose of testing the value of the method. The correlation is good. The minerals A to F are identified as follows: A and B are quartz and calcite, respectively. C very definitely matches the calculated pattern for dolomite. D and E show fewer lines, and at this time their identity is not as certain as those already mentioned. D matches the pattern for strontianite. E seems to be aragonite. Work is in progress to confirm the constitution of these components. F is probably a clay.

The apparatus is somewhat expensive and the operation consumes a little more time than use of the microscope, but if such work is referred to a special laboratory it will show advantages, especially when more correlative data have been accumulated.

Darrow Salt Dome, Ascension Parish, La.—Caroll E. Cook, in BULLETIN AM. ASSOCIATION PETROLEUM GEOLOGISTS, Vol. 22 (1938), No. 10, pp. 1412-1422.

Darrow salt dome is located on the east bank of the Mississippi River between Baton Rouge and New Orleans, 30 mi. southeast by road from Baton Rouge and 75 mi. northwest from New Orleans. It is the first salt dome east of the Mississippi River on which oil in sustained commercial quantities has been produced. The proved area at the end of 1937 was about 40 acres, as determined by data from the 30 wells drilled, of which 11 produced oil in some quantity.

Production on the dome has been obtained from super-cap sands and from flank sands, both of which probably represent the same Miocene horizon. A small amount of oil was produced from sands above the cap rock, but the most important production has been secured from what appears to be the same paleontologic horizon faulted to the 5,700 and 7,000 ft. levels.

The highest part of the dome is 4,627 ft. below the surface. At the 6,000 ft. contour the salt mass is practically circular in plan with a diameter of 4,800 ft. based on present data.

The usual difficulties attendant on pioneer development of piercement-type domes have been experienced in operations at Darrow, among them being the problem of locating the narrow productive zones, the faulting which has interrupted the peripheral continuity of these sands, and the lack of recognizable datum beds above the the oil sands

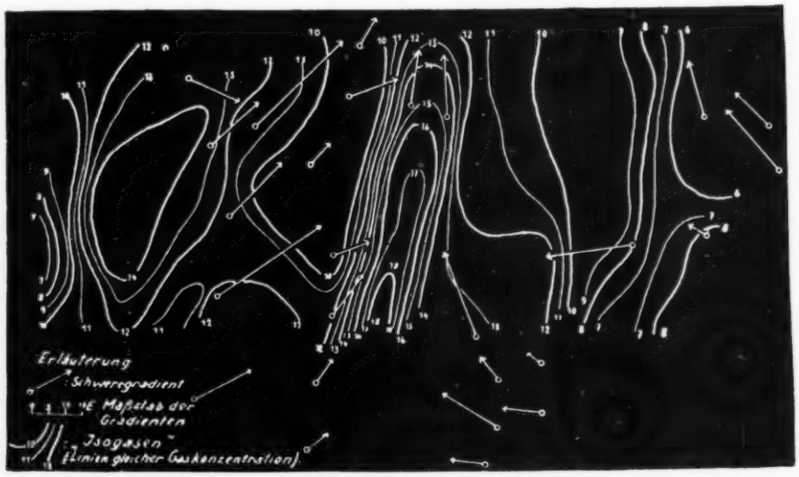
The deepest well on the dome was abandoned dry at 7,980 ft. in shale of Oligocene age, which is the oldest geologic formation reached on the structure to date.

GEOPHYSICS

Results of Gas Measurements in the Soil Above Oil Fields—G. Selzer and R. Weber, in PETROLEUM, Vol. 34 (1938), No. 39, 40. pp. 11-13.

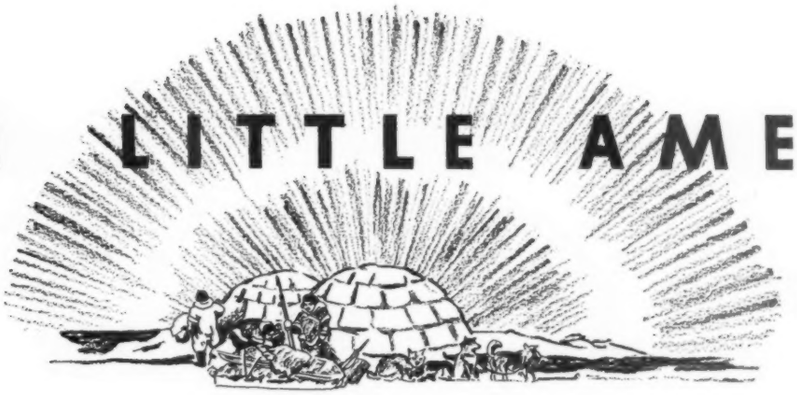
The authors report on the results of a soil-gas (methane) survey made by them in the Mur Island region (Mursco Sredisce) of Yugoslavia, where indications of petroleum deposits have been observed. The region is a plain where thick tertiary clay and marl formations are deeply covered with deposits of loess that completely obscure the surface geology.

The accompanying sketch shows the isogas lines (contours) as determined by the authors and the gravity gradients (arrows) as determined by an independent survey with the torsion balance. The isogas lines define an almost symmetrical maximum, which agrees well with the indications of a structural saddle revealed by the torsion balance survey. Both surveys thus point to the existence of underlying hydrocarbon deposits, which remains to be confirmed by the drill.



WORLD WIDE EXPERIENCE

FROM LITTLE AMERICA



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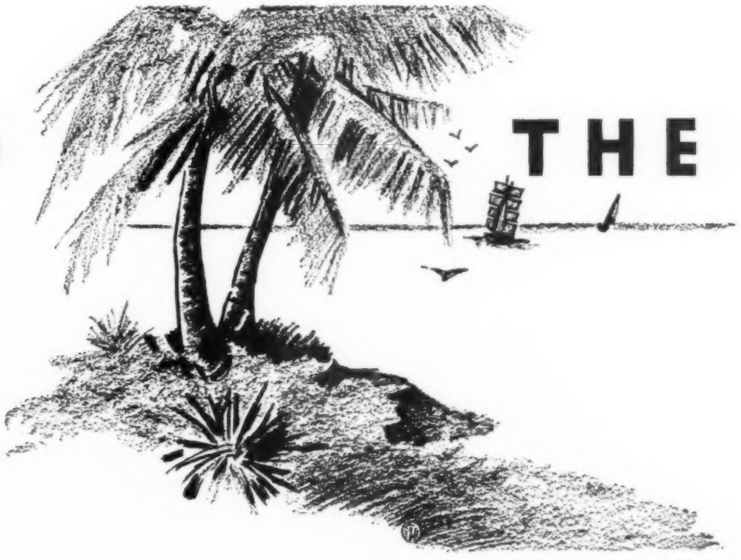
TO THE TROPICS



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DRILLING

Bullets for Coring Side Walls—Denis S. Sneiger, in OIL WEEKLY, vol. 91 (1938), No. 3, pp. 46-48.

Bullets have already been used for perforating casing strings opposite oil bearing strata; a new use of the same principle is to obtain cores from formations that have been penetrated by the well hole.

For this purpose an instrument is lowered into the hole by means of the standard cable used for electrical surveys; the outfit consists of one or more housings, each containing three to six bullets; each bullet is fired separately by electrical means. The bullet itself is a cylinder open at both ends; the gunpowder charge is sufficient to drive the cylinder into the side wall to a depth of about 1¼ inches; removal of the bullet and its core is accomplished by wires. It is possible to obtain six cores at a 6,000-ft. depth in about 1½ hr. The cost is therefore relatively small.

The instrument has been in successful use in the Gulf Coast and abroad and is no longer in the experimental stage.

Determining the Suitability of Oil Well Cement—John E. Weiler, in PETROLEUM ENGINEER, vol. 9 (1938), No. 13, pp. 33-34.

The constant advance in the technique of oil well cementing is exemplified by the manufacture of cements especially adapted to the several general types of cementing jobs. Among the factors determining the suitability of a cement for a particular job the following are deemed most important (1) time required to attain a consistency beyond which the cement would be no longer pumpable under average conditions; (2) the consistency during the pumpable period as defined in (1) above; (3) the effect of temperature on the length of the pumpable period as defined in (1) above, and on the consistency as defined in (2) above; (4) the rate of attaining strength after being placed; (5) the ultimate strength of the cement, and (6) the effect of temperature on the rate of attaining strength and on the ultimate strength.

The methods and apparatus used in testing cement to be used at the surface are of little value in testing oil well cement. This is particularly true of the tests for determining the setting time and consistency, principally because there is no similarity between conditions of the tests and conditions imposed by oil-well cementing.

The least that the engineer can do is to simulate conditions that are common to all types of well cementing; among others it is necessary to take into consideration the temperature to be encountered and the properties of the cement as regards consistency. As a contribution to this problem the author describes a cement Consistometer which has recently been designed and found satisfactory by a number of cement manufacturers and oil companies.

Effect of Temperature on the Gel Strength of Some Gulf Coast Drilling Muds—B. I. Routh and B. C. Craft, in PETROLEUM TECHNOLOGY, August, 1938; T. P. No. 961 of the American Inst. M. and M. Engineers; 7 pages.

The present era of deep drilling is also an era of high temperatures in the lower depths of deep wells, which raises a question as to the gel strengths of drilling muds. The authors made a new investigation of the subject and from a consideration of the results obtained in their experiments, the following will apply to field operations. The mud in the bottom of the hole will have a greater shear strength due to the increase in temperature over surface conditions. The increase in initial shear strength will tend to keep the cuttings removed from the bit and lower portion of the hole. The increase in 10 min. shear strength will, in the case of a shutdown, hold the cuttings in suspension and prevent excessive settling. Conversely, this increase in shear strength may prove detrimental, as it will hold gas as easily as it will cuttings, which may lead to a blowout. While breaking circulation, a mud with high shear will require high pump pressures, and during cementing operations the cement may channel, with a resulting failure of the cement job. Also, a high shear-strength mud may prevent the use of wire-line equipment.

At some critical temperature the maximum degree of gelation is reached. Above this temperature the shear strength remains constant.

Both initial and 10 min. shear strengths are decreased by chemical treatment. However, the reduction of initial values is small for muds of low shear strength.

The cylindrical shearometer is of better design than the rectangular type because it will not tip as readily, which greatly increases the ease and accuracy of operation; and it is more readily adapted to field use than the Stormer viscosimeter.

No definite relation seems to exist between viscosity and shear strength.

Carbonate Mud and Its Removal—O. N. Maness, in PETROLEUM WORLD (Calif.), vol. 35 (1938), No. 9, pp. 23-25.

Oil-well engineers have been experimenting with carbonate muds since 1918. The idea is that by having lime carbonate in the mud sheath on the well wall in the oil sand it will be easier to remove the sheath by means of acid and thus allow the well to produce.

This proved at first to be easier said than done, and it was not until methods had been revised and improved with added experience that more and more California oil companies have adopted the use of carbonate-prepared mud and its removal by chemicals as a regular part of well completion. The chief points of the latest methods provide for removal of the carbonate mud sheath by chemicals before oil is permitted to enter the well bore, and for proper agitation of the acid in the well.

The present standard practice in California for preparation of carbonate mud requires the addition of 30 lb. of ground limestone or calcium carbonate for each barrel of drilling mud in the system. This corresponds to a calcium carbonate content of 20 to 22 percent based on the total suspended solids present. According to Miller and Shea, 20 percent calcium carbonate in the mud is somewhat more than that necessary for complete disintegration of the carbonate mud sheath.

The method calls for close supervision of the content of carbonate mud while drilling through the oil formation, as there is a tendency for the carbonate to settle out in the mud pit, and hence the mud sheath will not have the proper composition. Also, special washers are used to insure proper action of the acid on the mud sheath.

OPERATION

Some Considerations in the Selection and Installation of Gravel Pack for Oil Wells—C. J. Coberly and E. M. Wagner, in PETROLEUM TECHNOLOGY, August, 1938, T. P. No. 960 of the American Inst. M. and M. Engineers, 20 pages.

Sand produced with the oil in many fields is one of the major causes of wear and down time on pumps, tubing, gas anchors and other equipment. Arresting this production of sand at its source would materially increase the life of such equipment and reduce production costs.

It is possible materially to reduce or eliminate sand trouble in some fields by the judicious selection of the openings in perforated liners. In other fields this is impossible because of fineness of the sand, poor compaction of the formation, low bottom-hole pressures, or other conditions. In such cases gravel packing seems to offer a practical and relatively simple solution of the problem.

Gravel packing of wells is not new. However, the selection and placing of the gravel heretofore have not been given sufficient study, and for that reason the results often have been unsatisfactory. An analysis of the problem is presented to show that gravel packing can be put on a rational basis and made a practical method of correcting a condition that has been a constant source of trouble to the oil industry. Three problems are considered: selection of the proper mesh gravel to hold the formation in question, proper placing of the gravel, selection of a properly perforated liner to hold the gravel.

Selection of the proper liner presents little difficulty, as the perforations should be small enough to hold back the smallest grains in the gravel pack. The selection of the proper mesh gravel is more complicated, but in general it is assumed that satisfactory bridging of the gravel will be obtained if the openings between grains are twice the diameter of the smallest 10 percent of the grains (the 10 percentile). Packing gravel is usually considered to be of ¼ or ⅜ in. size; the largest that would be used in six to eight grain size.

The authors give detailed directions on the necessary preparations in the well to receive the packing gravel, and on the method of putting the gravel in place. It should be mixed with a heavy liquid that is soluble in the crude oil of the well, and the mixture should be fluid enough to be pumped. An oil suitable for the purpose is known as S. R. stock from Oklahoma City crude.

Stage Separation of Crude Gas-Oil Mixtures—G. O. Kimmell and R. L. Huntington, in OIL WEEKLY, Vol. 91, (1938), No. 6, pp. 60, 44, 46, 48, 50.

With the promotion of repressuring and pressure maintenance come problems of high pressure separation of oil and gas. Here multi-stage separation comes into prominence. Stage separation is a method of producing crude oil or distillate by subjecting the well stream to a series of flash vaporizations in successive pressure reductions.

As there seemed to be no quantitative study of stage separation of a volatile charging stock at high pressures, the authors made such a study, using a mixture of Oklahoma crude oil, butane and a dry natural gas. Among the variables that came into consideration the relationship of the pressures between the successive separators proved the most interesting. A constant stage pressure ratio of about 4.50 to 1 between each successive stage gave the lowest overall gas oil ratio and the highest gravity crude oil. These ratios will naturally vary in different fields but the technique described will help to show the proper ratios in particular cases.

Chemical Removal of Carbonate Scale—O. N. Maness, in OIL WORLD AND PETROLEUM INDUSTRY, Vol. 31 (1938) No. 20, pp. 6-12.

One of the troubles in the operation of oil wells that also produce quantities of reservoir water containing calcium or magnesium carbonates (or both)

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is the formation of crusts or scale on the face of the pay sand, or on the perforated liner opposite the producing formation. The character, porosity and hardness of such scales vary in different wells but they all have the effect of impeding if not preventing the free flow of oil, and the question of their removal will arise. There is usually only one way to effect its removal, which is by an acid treatment; the acid most convenient to use for the purpose is a 10 to 15 percent solution of hydrochloric. To get the most effective action by the acid requires much consideration and considerable skill.

In the first place the acid must contain an inhibitor that will prevent any appreciable action on iron; in the second place it must also include a wetting agent which will enable the acid to penetrate the layers of oil which cover the face of the formation and the surfaces of the perforated liner; in the third place account must be taken of the fact that hydrochloric acid tends to produce an undesirable sludge in some high gravity oils, and the composition of the acid must be varied to take care of this condition; in the fourth place judgment must be exercised as to the time and manner in which the acid is allowed to act and to keep it from penetrating too far into the formation where it will be wasted.

The technique of scale removal as developed in California is substantially as follows:

The fluid in the well is pumped off or lowered and 200 to 300 gal. of prepared acid are pumped slowly into the space between casing and tubing, the pump being kept going until the treatment is finished. Small applications of acid are repeated at regular intervals, these applications being spaced so that the amount of acid will not overbalance the normal pressure of the well fluid and thus be forced into the formation. Samples of fluid are taken from time to time until the spent acid reaching the top shows a slight acid reaction, which will indicate that most of the carbonate scale in the well has been removed, to clean up the job the fluid now in the well is circulated, without further addition of chemicals, for 8 to 24 hr.

The necessity for such treatment, and the result, are indicated by the history of two wells, one of which was producing only four barrels a day, and the other had gone dead. In the one case the normal production was increased 967 bbl. while the dead well produced 6,500 bbl. 78 days after treatment. The costs of acid treatment in the two cases were approximately $280 and $463.

NATURAL GAS

Why Not Eliminate the Waste?—E. F. Schmidt, before AMERICAN GAS ASSOCIATION, October, 1938.

The author points to the well-known fact that there has been a tremendous waste of natural gas in the United States. It has been argued that gas produced with oil and blown to the air is not waste because it has performed the necessary function of bringing the oil to the surface, but regardless of all pleas in justification the fact remains that gas blown to the air is waste from the standpoint of the producer and the gas industry (and it may be added from the standpoint of the public interest also—ED.).

The remedy is to return the gas to the reservoir, there to remain until it is needed. Of course, no producer will voluntarily return the gas to the reservoir after producing the oil unless he sees that his best interests will thereby be served, but it is a fact that his best interests will be served by such a course. It is beyond dispute that oil recoveries have been universally low under the usual methods of operation, being about 20 and at most 30 percent of the original reservoir content. On the other hand, it has been demonstrated that oil recoveries may be increased to as much as 75 percent by intelligent pressure maintenance.

Some operators have become well aware of this fact, and there are already a number of classic examples. In the Cook field (Shackelford Co., Tex.) the indicatd oil recovery without repressuring was 7,500,000 bbl. During the first 17 mo. production from 147 wells had declined to 600 bbl. a day. Ten years later, under a repressuring program in which nearly 9,000,000,000 cu. ft. of gas had been recycled to the formation, the production of the field has exceeded 13,000,000 bbl.; daily production is being maintained at 2,000 bbl., and the expectancy of the field has been raised to 20,000,000 bbl.

Another classic example is the Sugarland field (Texas) of the Humble Oil & Refining Company, where the reservoir pressure has been maintained at nearly the original pressure of 1,556 lb. per sq. in. since 1928. The Humble Company expects to recover more than 70 percent of the original oil content of the reservoir and in addition will have saved an appreciable gas reserve.

Another shining example is the Tepetate field of the Continental Oil Company in Louisiana where pressure maintenance by recycling the gas back to the formation was started after the bottom hole pressure had fallen from 3,640 lb. per sq. in. to nearly 3,000; the average production per pound of pressure drop was 3,650 bbl. After beginning recycling the gas at 4,000 lb. pressure production per lb. of pressure drop was increased to 200,000 bbl., and it is expected that ultimate recovery will be at least 40 percent more than may have been obtained without pressure maintenance. Experience in these three fields shows that the overall cost of pressure maintenance by recycling the gas is not more than five or six cents a bbl.

Gas Well Acidizing—O. W. Lyons, in OIL WEEKLY, vol. 91 (1938), No. 1, pp. 32-38.

The acid treatment of gas well now has a record of five years behind it, and the results have been commercially satisfactory.

Results obtained last year in the Texas Panhandle from a group of 47 treatments are analyzed. On an average the output of a well originally producing 5,000,000 cu. ft. of gas is increased to about 18,000,000 cu. ft., a 10,000,000 cu. ft. well is increased to 32,000,000 cu. ft., a 20,000,000 cu. ft. well to 45,000,000 cu. ft. and a 40,000,000 cu. ft. well to 75,000,000 cu. ft.

The actual economic value of acidizing treatment of gas well is further estimated by calculating the cost to the operator in obtaining a 1,000,000 cu. ft. open flow by drilling a well and producing from the well without acidizing, and producing from the same hole after acidizing. The figures quoted show that the cost of increasing the open flow capacity by 1,000,000 cu. ft. by acidizing is only $77, which is only 6.6 percent of obtaining the same capacity by drilling a new well, if neither of the two wells is acidized.

Recovery of Natural Gasoline by Dehydrating and Refrigerating Casinghead Gas—Don S. Wallace, in PETROLEUM ENGINEER, vol. 9 (1938), No. 13, pp. 70, 72, 76-77.

A plant for recovering natural gasoline from casinghead gasoline by a process of dehydration and refrigeration, said to be the first of its kind, is in operation at the Benavides (Tex.) plant of the Duval Gasoline Company, where 6,500,000 cu. ft. of wet gas is being treated daily. The wet gas is first scrubbed to remove liquids, compressed to 50 to 60 lb., and cooled to 40 deg. F. to remove some of the water and heavy hydrocarbons. Next the gas passes through a bed of granular dehydrating material which removes water vapor to such an extent that even at minus 50 deg. F. there is no condensation. After this dehydration the gas is cooled to a temperature of minus 35 deg. F., using liquid propane vaporizing at about atmospheric pressure as the cooling medium. The liquid hydrocarbons resulting from this cooling are separated and stabilized; the cold gases serve for cooling the feed gases and the cold liquids are also pumped through heat exchangers. The refrigeration cycle is a closed one.

REFINING

Cracking-Hydrogenation of Roumanian Fuel Oil—C. Candea and L. Sauciuc, in PETROLEUM, Vol. 34 (1938), No. 42, pp. 3-5.

Hydrogenation experiments were made at 410 to 440 deg. C. and various pressures on a cracked fuel oil residue boiling at 273 to 329 deg. C. using molybdenum trisulphide as a catalyst. Practically complete hydration was effected at 430 deg. C. and 300 atm. pressure.

The chief point of this investigation is that the ease of hydrogenation depends on the extent of the free reaction space in the hydrogenation chamber; where this chamber is only partly filled with oil the pressure of the hydrogen may be lowered.

Refining Gasoline with Solid Phosphoric Acid Catalyst—V. N. Ipatiaff and B. B. Carson, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 30 (1938), No. 11, pp. 1316-1317.

This paper describes experiments on the vapor-phase refining of gasoline with solid phosphoric acid catalyst. The investigation was the outgrowth of the observation that phosphoric acid catalyzes the decomposition of alkyl sulphates. For example, alkylated benzene produced by the interaction of benzene with olefins in the presence of sulphuric acid contains alkyl sulphates which render distillation impossible because of decomposition and accompanying oxidation by the liberated sulphuric acid. Contacting with a small amount of phosphoric acid not only decomposes these alkyl sulphates so that there is no decomposition on distillation, but it also benefits the color and gum of the distillate.

The charging stock was an untreated stabilized distillate from cracking West Texas crude. The solid phosphoric acid catalyst was prepared from a mixture of commercial orthophosphoric acid and diatomaceous earth (Sil-O-Cel). The plastic mass was heated at 250 deg. C. for several hours. After being cooled the solid cake was broken up and the material was screened to granules.

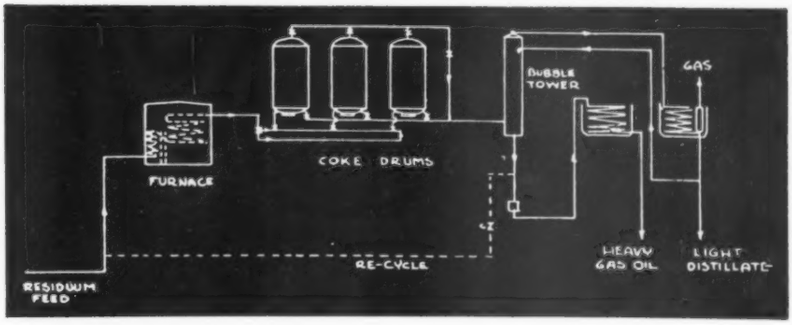
Pressure distillate was charged by a small pump, via a metal bath pre-heater, to an electrically heated catalyst chamber, whence it flowed by gravity to a fractionating column which separated the treated material into 400 deg. F. (204 deg. C.) endpoint gasoline and polymer. The former was immediately stirred with caustic.

Fresh catalyst produced the equivalent of 1,950 bbl. of distillate of 29 color (degrees Saybolt) per ton of catalyst; after standing over the week-end, the catalyst no longer produced distillate of satisfactory color. The procedure was to regenerate after each weekend shutdown. The production of refined gasoline after the first, second, third, and fourth

regenerations was equivalent to 1,200, 740, 950, and 725 bbl. per ton of catalyst, respectively.

The refining effect of Attapulgus clay was determined in the same apparatus (metal) and under the same operating conditions as with solid phosphoric acid catalyst.

The best results with clay corresponded to 115 bbl. of 27-color gasoline per ton of clay or 170 bbl. of 24-color, whereas solid phosphoric acid catalyst produced 1,950 bbl. of 29-color gasoline per ton of catalyst (without regeneration) or 5,565 bbl. of 27-color (with regeneration). Moreover, the phosphoric acid catalyst allowed a faster feed rate than the clay.



Influence of Doctor Sweetening on Inhibitor Susceptibility of Cracked Gasoline—C. D. Lowry and others, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 30 (1938), No. 11, pp. 1275-1279.

Improper doctor sweetening, particularly the use of excess sulphur, has been found to influence adversely the effectiveness of oxidation inhibitors in sweetened gasoline. By sweetening at a temperature not below 85 deg. C., properly mixing gasoline, doctor solution, and sulphur, and allowing adequate settling time, doctor sweetening can be carried out with a minimum amount of sulphur and produces a gasoline in which the inhibitors will be consistently effective. The harmful effect of excess sulphur is apparently due to the formation of polysulphides, particularly those higher than trisulphides, which remain in the gasoline. Equations are presented to account for the formaton of these polysulphides.

Continuous Coking by the Delayed Coking Process—R. J. Diwoky, before AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1938.

The widespread use of coking in present-day refining operations can probably be attributed to the higher gasoline yields obtainable by this process. The high cost of the earlier methods of conventional batch-still coking has led to the development of continuous coking methods which offer appreciable advantages over the older method. The delayed coking process developed by the Standard Oil Company (Indiana) has been in commercial operation for several years, and is superior to the batch-still method in many respects.

This process is based on the principle of rapidly heating the stock to be coked to a high temperature and charging the heated material into a vertical coking drum, where coking is effected by means of the contained heat. Thus, while the temperature of the residuum leaving the heating coil is sufficiently high to cause coking, the time of contact in the furnace is short, and actual formation of coke is delayed until the stock is introduced into the coking drum. This has suggested the name of delayed coking.

The coking unit described herein has a capacity of 2,860 bbl. (42 gal.) per day of Mid-Continent reduced crude of a gravity of 19.0 deg. A.P.I. A simplified flow sheet of this unit is shown. The Mid-Continent residuum at a temperature of 685 deg. F. is withdrawn from a crude-reducing unit (not shown) and pumped to the furnace, where it is heated to coking temperature.

Operation of the unit as a whole is continuous. In normal operation each drum is filled with coke in 36 hr. During the latter part of the coking cycle on each drum, the hot overhead vapors are passed downflow through the next drum to be used in order to preheat this drum in preparation for receiving the stock to be coked. When the desired amount of coke has accumulated in the first drum, the hot feed is switched to the second drum. The first drum is allowed to stand for 24 hr. in order to increase the hardness and decrease the volatile matter content of the coke. The drum is then cooled by steaming for 15 min., followed by water cooling for one hour. The drum is then ready for cleaning.

The yield of stabilized gasoline of 400 deg. F. end point is 22.4 percent of the residuum charged to the coking unit. This gasoline has an A.S.T.M. octane number of 55.0, and a Reid vapor pressure of 8.0 lb. per sq. in.

The ultimate gasoline yield, including that from cracking the coke-still gas oil, can be improved by recirculating the heavy ends of the coke-still gas oil within the coking system. This principle was employed in the construction of a large combination crude-distillation, gas-oil-cracking, and coking unit which recently started operation. The coking system of this unit is similar to that described above, except that it is integrated with the cracking and distillation system and charges, in addition to reduced crude, heavy re-cycle stock boiling above about 850 deg. F. from both the coking and cracking systems. It has been possible to achieve a close balance between the coking system and the crude-distillation and gas-oil-cracking systems.

Hydraulic De-Coking of Coke Chambers—W. F. Court before AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1938.

In this process high impact-producing water jets are utilized for discrupting the coke bed. A comparison of actual results obtained by cable and hydraulic systems revealed a reduction in clean-out time of at least 50 per cent in favor of the hydraulic system—with 67 percent a frequent occurrence.

The new system effects large savings in the elimination of cable, cable hooks, clamps, and fastening wire. In addition, there is an appreciable saving in labor cost—the installation having made possible the reduction of the crew from 20 to 11 men in one plant.

The process does not require men to enter the chamber at any time, because the jets remove completely all coke from the chamber wall—thus one of the most hazardous and unhealthful functions of a clean-out crew has been eliminated.

The use of water as a means for disrupting and removing coke from a chamber now makes possible the use of pumps instead of railroad cars for transporting coke to the yard pile, hoppers, or screens. Again, with the use of water, there are indications that a solution to many of the coke-degradation problems will be found.

The hydraulic pumps are driven by electric motors especially built for the cycle of operations. A standby high-pressure pumping unit is provided on the Wood River installation.

Experience to date indicates that the cost of maintenance of the jetting nozzles is low. They are equipped with renewable tips which obviate the necessity for replacing a complete nozzle when wear occurs.

Tests have indicated that the cutting action of the jets has no effect on the steel walls of the vessels.

The swivel joints used in the piping linkage between the high-pressure header and the stem are standard equipment, and the expense for their maintenance to date has been negligible.

The hydraulic method of decoking chambers and the hydraulic method of conveying coke away from chambers are covered by patents and patent applications owned by Shell Development Company, Worthington Pump and Machinery Corporation, and The Allen-Sherman-Hoff Company.

Revivification Characteristics of Bauxite Used in Percolation Filtration—R. H. Hubbel, Jr., and R. P. Ferguson, before AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1938.

Investigation of the effect of continued revivification on the adsorptive qualities of bauxite reveals that the revivification characteristics of this material vary with the type and source of stock handled and the method of filtration substantially as follows:

In the solution percolation of residual stocks bauxite retains throughout its life an efficiency of approximately 85 percent of its initial value.

In the straight percolation of bright stocks, average values in the vicinity of 80 percent of new material are obtained.

The bauxite filtration of distillate stocks requires the maintenance of low temperatures of revivification. Under optimum conditions values of 55 to 60 percent of No. 1 bauxite are maintained in the percolation of Pennsylvania neutrals.

Bauxite manifests a great advantage over other adsorbents in the percolation of petrolatums and related stocks, owing to the high yields and the tasteless and odorless character of the products.

Fresh bauxite exerts a solvent action greater than that of fullers earth, a characteristic which diminishes with repeated re-burning. With fresh material, improved carbon and increased A.P.I. gravity are obtainable, but only at some sacrifice in viscosity.

Generally satisfactory results were obtained on Pennsylvania cylinder stock, acid-treated mid-continental residuals, bright stocks and neutral distillates. However bauxite rapidly loses efficiency in filtering and acid-treated Colombian distillate stock as compared with fullers earth; hence it cannot be used with advantage on such stocks unless operations are balanced so as to permit use of No. 1 and No. 2 only, thereafter utilizing the material for residual stock filtration.

The percolation of petrolatum is, unquestionably, the service in which bauxite shows to the greatest advantage, inasmuch as the efficiency of bauxite as compared to fullers earth frequently approaches 500 to 600 percent by volume for new low-burned material.

Transformation, by Polymerization, of Medium Shale Oils into Aromatic Hydrocarbons—Ch. Berthelot, in MONITEUR PETROLE ROUMAIN, Vol. 39, (1938), No. 16, pp. 1317-1318.

The author (a French engineer) regards the Roumainian process of obtaining high-grade gasoline from middle distillates, such as kerosene and gas oil, as a distinct progress. In this process the starting material is vaporized and passed through separate furnaces, each maintained at a definite temperature at which specific decomposition and polymerization reactions occur.

The Roumanian process involves four stages, as follows:

I. 320 deg. C.

Complete vaporization of kerosene.

II. 500-520 deg. C.

Decomposition of higher paraffins into olefins and lower paraffins;
Decomposition of C_7 and C_8 paraffins;
Formation of propylene and butylene;
Isomerization of the olefins;
Rupture of the side chains of simple and polycyclic naphthenes;
Initiation of polymerization of the olefins.

III. 600-620 deg. C.

Polymerization of the olefins into cycloparrafins and cycloolefins;
Addition reactions;
Partial dehydrogenation of the naphthenes of the kerosene.

IV. 720-740 deg. C.

Polymerization of the gaseous lower ethylenes;
Dehydrogenation of the polymerized cycloparaffins;
Light decomposition of the naphthenes into paraffins and olefins,
Formation of paraffinic polycyclic hydrocarbons of high molecular weight.

It is possible to control the reactions according to the above outline without catalysts by a strict regulation of the temperatures in the different stages and an exact calculation of the heating surfaces. Under such conditions the yields are said to practically coincide with theory. There is no coke formation and a minimum of final gaseous products. In a laboratory run on 809 gr. of kerosene (1,000 cc.) the following was obtained within the temperature range 340-735 deg. C.:

	Grams	Liquid Grams	Gas, Grams	Total Grams
Paraffin	446.3	22.05	97.4	119.45
Olefins	20.2	58.95	25.6	84.55
Naphthas	229.5	50.00	....	50.00
Aromatics	113.0	524.00	....	524.00
Loss	....	....	....	31.00

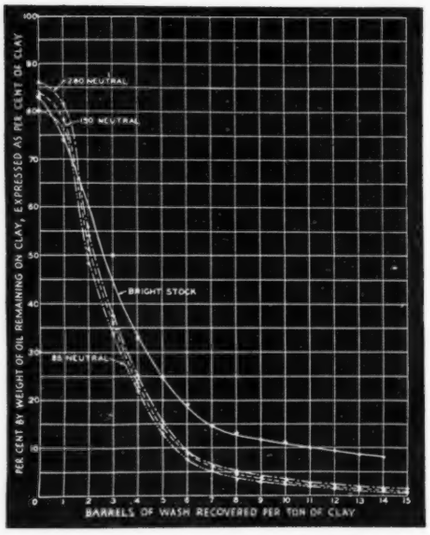
The boiling range of the product is 58-167 deg. C., the octane number 92 (C.E.R.), copper dish 1.6 mg., Reid vapor tension 0.23 atmos., Doctor test negative, Bromine number 1.00, cold point below minus 40 deg. C. The gasoline contains 83.2 percent of aromatics, and the process affords an easy way to prepare large quantities of benzene and toluene.

Study of the Recovery of Oil from Spent Percolation Filters—C. M. Ridgway, L. M. Henderson and W. B. Ross, before AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1938.

A study was made of one of the important factors influencing percolation costs, viz., the recovery of the oil remaining in the filter when the absorbent is spent. In the process of this investigation the factors involved in the two operations of filter draining and filter washing were studied.

The following general observations and conclusions were drawn from the data obtained.

In plant filters the rate of draining and the total amount drained are dependent primarily upon the condition of the screen.


PER CENT BY WEIGHT OF OIL REMAINING ON CLAY, EXPRESSED AS PER CENT OF CLAY
ZERO NEUTRAL
150 NEUTRAL
BRIGHT STOCK
BS NEUTRAL
BARRELS OF WASH RECOVERED PER TON OF CLAY

In naphtha washing a low uniform washing rate is desirable.

The first portion of the washing naphtha should be applied at a temperature below that of the filter, and in such volume as is necessary to remove the filterable oil. The subsequent washing naphtha should be added at a temperature above that of the filter for the purpose of dissolving an increased proportion of the tar.

A paraffinic naphtha of low vapor pressure and low end point should be used in washing.

An appreciable increase in the viscosity of the original charge increases the amount of naphtha necessary to reduce the oil content of the filter to a specific magnitude.

The color of the cylinder stock recovered in the wash is not indicative of its filterability.

The filterability of the oil contained in the washings is at present the only criterion that can be used in judging the fraction to be returned to the blend tank for re-processing.

Clay-wash cylinder stock should not be blended with stocks of better filterability, inasmuch as this material decreases the filter yields to a much greater extent than its arithmetical proportion.

When re-cycle wash is used, extreme care must be taken to avoid introducing into the system material of poor filterability.

The quantitative relation between oil recovery and barrels of wash naphtha used are shown in the accompanying diagram.

CHEMISTRY

Deterioration of Turbine and Transformer Oils in Service—W. Francis and K. R. Garrett, in JOURNAL INSTITUTION PETROLEUM TECHNOLOGISTS, vol. 24 (1938), No. 178, pp. 435-440.

Transformer and turbine oils are normally exposed to similar relatively low-temperature conditions, without cracking or formation of free carbon. The exchanges that occur are considered to be, first, the introduction of oxygenated groupings into the oil molecules, followed by a splitting off of fatty acids, leaving a residue of unsaturated molecules which either polymerize or condense with the oxygenated products to form sludge. The formation of acids is not considered especially serious unless excessive; sludge is the real trouble maker. Acidity is the best estimated by titration with thymol blue as indicator.

The authors make use of the Grignard reagent for investigating the oxygenated groupings that have been introduced by aging into the oil molecules. A known weight of the oil is dissolved in xylene (dried over sodium), the mixture is placed in a Lunge nitrometer and an excess of amul magnesium iodide is added. On shaking, much of the methne formed is immediately liberated, the rest more slowly. This test shows that the amount of oxygen present in used oils is much greater than would be expected from the acidity figures, which indicates that considerable oxygen may be taken up as hydroxyl, aldehyde or ketone without formation of acid radicles.

This use of the Grignard reagent throws new light on the possibilities of reclaiming oils that have deteriorated in service. Repeated extractions (seven times) of a highly oxidized oil removes 82.5 percent of the total reactive oxygenated groupings and 94.5 percent of the total acidity. The recovered oil agrees well with the standard test figures for the original oil, and is perhaps better than the original because the groupings liable to oxidation have been removed. Although there may be difficulties in the way of its commercial application, alcoholic extraction is an effective method of reclaiming deteriorated turbine oils.

The same type of result may be obtained by treating a highly oxidized oil with active earths, but the effect is not so pronounced as with exhaustive extraction with alcohol.

Dehydrogenation of Lower Paraffins by Catalysts—J. Burgin, H. Groll and R. M. Roberts in OIL & GAS JOURNAL, vol. 37 (1938), No. 17, pp. 48-55.

The lower olefin hydrocarbons, propene, butene and isobutene, which were formerly regarded as undesirable by-products of oil cracking operations, have now become of great interest as source materials for synthetic chemical products, and especially for higher grade gasolines. This situation is developing to such an extent that a shortage in the supply of these olefins from the usual sources is imminent. In anticipation of this shortage the Shell Development Company has embarked on a study of processes for increasing the supply. This paper is a report on one of these processes—the catalytic dehydrogenation of propane, normal butane and isobutane.

Olefines can be produced by cracking (pyrolysis) of hydrocarbons, but this treatment is drastic and rather uncontrollable, and the yield of olefins is small. The optimum temperatures of olefin formation are lower than that used in cracking, but to obtain satisfactory yields the operation at these lower temperatures must be assisted by a proper catalyst, which also must be chosen with regard to the thermal stability of the hydrocarbon.

From this research it appears that the most suitable catalyst is a form of activated alumina of porous structure that is now being sold as a drying agent; an activated alumina that compares very well with the commercial product can be prepared in the laboratory by precipitating a solution of sodium aluminate with carbon dioxide and drying the carefully washed product at 600 deg. C.

For the dehydrogenation of isobutane with this reagent the optimum temperature is 585 deg. to 650 deg., for propane 625 deg. to 650 deg., depending on the rate of passage; little reaction takes place below 550 deg. The gas must contain a certain amount of water (0.1 mol. percent) for satisfactory dehydrogenation.

While activated alumina is a good dehydrogenation catalyst in itself its usefulness is increased by employing it as a carrier or support for other ac-

14
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tivating materials. In this connection a coating of 2 to 12½ percent of chromium oxide gives good results. The optimum temperature of dehydrogenation is lowered 50 deg. to 70 deg. C.; the initial conversions are higher, the ratio of isobutene to total olefins is better and the yields are higher, amounting to 75 to 80 percent at space velocities between 20 and 75 per min. at 550 deg. to 600 deg. C.

The activity of the catalyst declines as a result of the accumulation of carbon on the surface and in the pores. Regeneration may be effected by treating the catalyst at 600 deg. to 700 deg. with a stream of air, diluted with an inert gas such as nitrogen, carbon dioxide, or in certain cases, steam.

PHYSICS

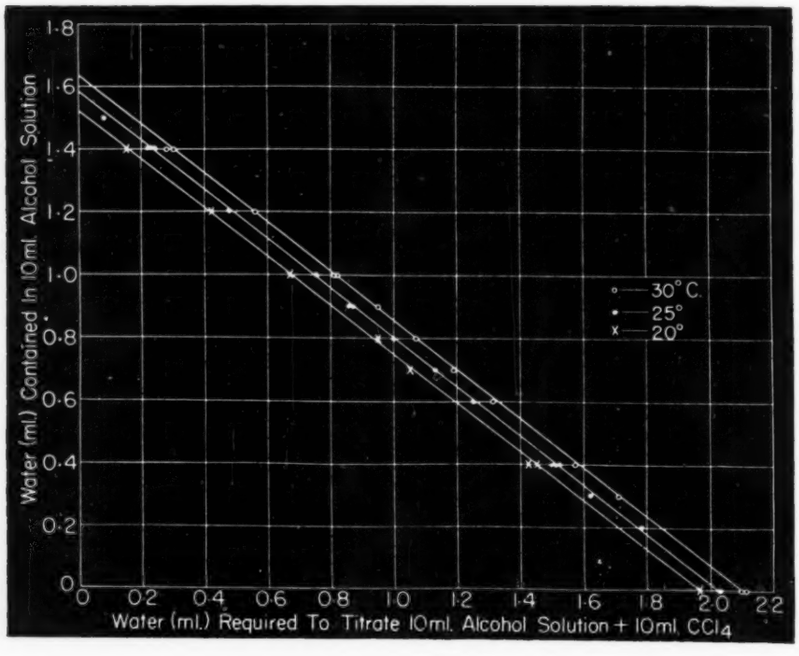
A Method of Determining the Water Content of Sands—H. G. Botset, in PETROLEUM TECHNOLOGY, August, 1938, T. P. 972 of the American Inst. of M. and M. Engineers; 7 pages.

It is now a generally accepted fact that practically all oil sands contain some free water, even when the oil produced from these sands is water-free. No rapid and reasonably accurate method of measuring the water content of sand cores having been found in the literature, the author gives a procedure that has been developed from methods used in measuring the water content of alcohols, and in the study of gasoline-alcohol mixtures where small quantities of water disturb the solubility relations.

If 10 ml. of absolute alcohol (200 proof) is mixed with 10 ml. of carbon tetrachloride and titrated with water, no cloudiness will appear until 2.03 ml. of water has been added at 25 deg. C. If the alcohol already contains some water, a smaller volume of titration water will be needed to produce cloudiness; the difference between the ml. of titration water used and 2.03 ml. gives the amount of the water originally present.

As applied to determination of the water content of oilfield cores, the sample is crushed and the oil it contains is extracted and washed with carbon tetrachloride; at the end of this operation a known volume of the wash liquid remains with the sand. An equal volume of absolute alcohol is added and the mixture titrated with water until a permanent cloudiness appears. The cloud point depends on the temperature, so the results have to be referred to the temperature at which the test was made. A graph for use between 20 deg. and 30 deg. is shown herewith.

Both absolute alcohol and carbon tetrachloride are volatile and the alcohol is hygroscopic; hence appropriate precautions must be taken. The method is rapid (15 minutes) and sufficiently accurate.



Influence of Oil Flow on Water Content of Sands—Nico van Wingen, in OIL & GAS JOURNAL, Vol. 37 (1938), No. 23, pp. 56, 57, 64, 66.

The main result of this research is to confirm the fact that oil flowing through a sand may issue from a well with no trace of water, although the sand may contain water to the extent of 40 percent of its pore space. The amount of water actually retained when oil under a constant head is flowed through an unconsolidated sand is inversely proportional to the specific permeability of the core. The amount of this residual water is apparently to some extent independent of the pressure of the oil, evidently due to the fact that the capillary attraction of the sand is greater than for oil.

Piezo-Electric Motor Indicator and its Use in the Investigation of Fuels—H. Hintze, in PETROLEUM, Vol. 34 (1938), No. 41, pp. 1-6.

It is well known that when a quartz crystal that has been cut into plane surfaces parallel to the so-called electrical axis of the crystal is subjected to pressure, an electrical charge is generated which is proportional to the pressure.

This principle has lately been utilized for investigating the pressure generated in the combustion chambers of explosion engines. A cartridge containing a suitably prepared crystal is screwed through the wall of the cylinder so as to present a surface flush with the interior of the cylinder. At the outer end of the cartridge arrangements are made to amplify the weak piezo-electric current and to use it for deflecting a beam of light falling on a small mirror; the path of the beam of light is recorded photographically. The result is a diagram which contains a record of the energy produced by every single stroke of the engine even when operating at 3,000 r.p.m.

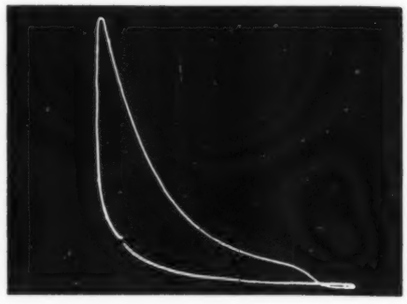


Figure 1

Figure 1 shows a pressure-stroke diagram obtained on an Otto engine rotating at 3,000 r.p.m. Figure 2 is the pressure-time diagram of a Diesel motor.

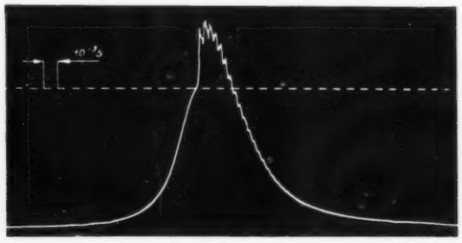


Figure 2

Aside from this application to the study of fuels for internal combustion engine, the piezo-electric principle, which has long remained of merely laboratory interest, has now found wide use as a means of measuring and controlling industrial operations.

ASPHALT AND TAR

Evaluation of Bituminous Mixtures—Herbert Kamptner, in PETROLEUM, vol. 34 (1938), No. 36, pp. 1-8.

The crushing strength of a road surface consisting of bitumen or asphalt and a mineral aggregate is of recognized importance and is determined by a standardized method. The shearing resistance of such materials seems to have received less attention. This is of importance on highways designed for heavy freight truck traffic, where sudden braking of a fast-traveling, heavily loaded truck puts a severe strain on the highway material.

For this test the author proposes the arrangement shown in the sketch on page 64. A dimensioned small block of the paving is fixed so that pressure may be applied from above on part of the top of the block which is unsupported below. The test piece, so arranged, is put in a screw press equipped with a pressure indicator and the force required to shear the block is noted. Both vertical and horizontal shearing may be measured (on separate test blocks). The accuracy is well within four percent. The materials used for the test should

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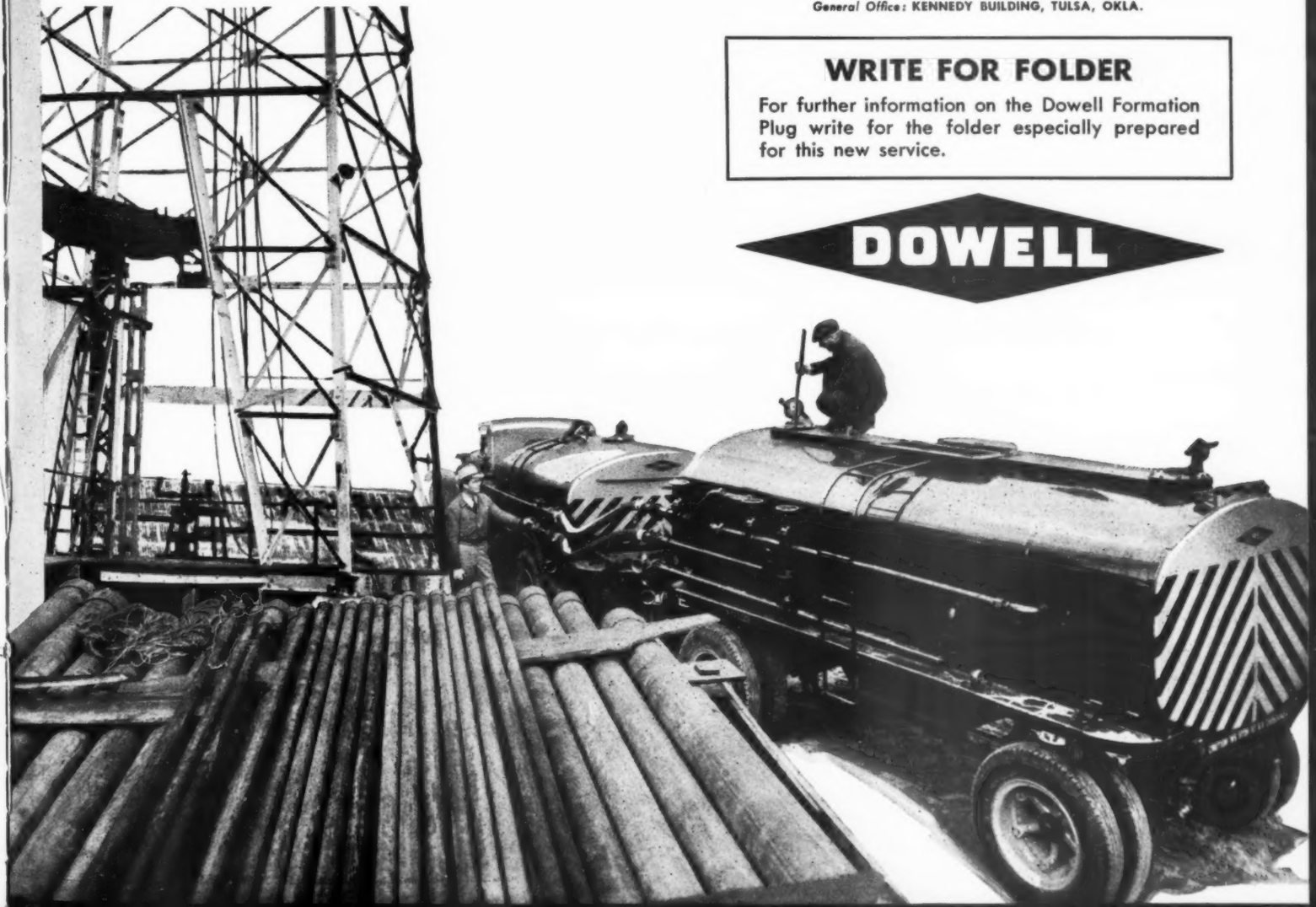
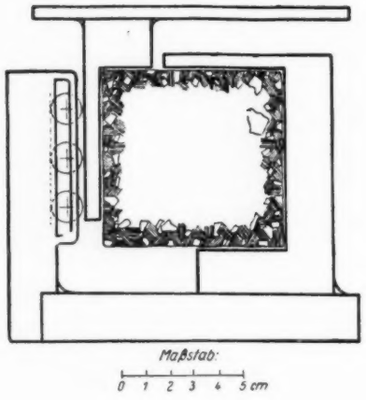


OIL AND GAS WELL CHEMICAL SERVICE

be machine mixed. As is to be expected, aggregates made with broken stone have higher resistance than aggregates made with rounded sand or gravel.



GENERAL

Calculation of Venting Requirements for Low-Pressure Oil Storage Tanks—Louis Bosa, before AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1938.

Oil storage tanks breathe on account of temperature variations or during filling and emptying operations. Breather valves allow a tank to breathe while limiting at the same time the evaporation losses. The size and number of breather valves required in a certain installation depend upon the maximum probable breathing rate, in cubic feet per hour.

An investigation of the methods used for the calculation of venting requirements has led the author to submit a standard method of calculation, flexible enough to fit varying conditions, and insuring at the same time the necessary degree of safety. A nomographic chart is appended to simplify the numerical computations.

Evaporation Losses of Petroleum Oils from Steel Tanks—C. C. Ashley, before AMERICAN PETROLEUM INSTITUTE, Chicago meeting, November, 1938.

The study upon which this report is based was undertaken in an effort so to correlate and compare all available data on tank evaporation losses that charts might be prepared to assist in the prediction of evaporation losses from petroleum oils in standing storage and while these oils are being pumped into tanks.

A detailed review of a large amount of data on evaporation losses indicates that much of the information that has been published as comparable is not comparable, because there has been no common basis for comparison. Methods of presentation used have not included enough of the many variables affecting evaporation losses to insure results truly representative or comparable.

The charts presented herein are based on a factor which is believed to be the most comprehensive of any so far used in this work, and upon which adequate correlation of tests made under widely variable conditions can be accomplished. This factor is vapor pressure of oil at average temperature of oil in tank.

Two charts, which can be used for the prediction of losses, are presented: evaporation loss of petroleum oils from standing storage in steel tanks, and evaporation loss of petroleum oils due to pumping into steel tanks. The data upon which these charts have been prepared are rather meager, and the charts, consequently, are subject to revision as additional information becomes available.

Incidental to the preparation of the charts, it has become evident that there is a real need for a uniform procedure for conducting evaporation-loss tests which can be adopted generally, and which will facilitate coordination of results secured by different investigators. A suggested procedure is presented in the appendix to this report.

The requirements can be met by adherence to the following principles:

1. Take all oil samples, and make all gaugings between the hours of 2:30 and 5:30 a.m., which is the period when greatest uniformity of atmospheric and tank conditions exists.
2. Conduct all evaporation-loss tests by the vapor-pressure method, using the apparatus and procedure of Chenicek and Whitman.
3. Take all samples in accordance with the procedure recommended by Chenicek and Whitman, until a better method is developed and proved—when it should be adopted.
4. Every test should include the following data in addition to the Chenicek and Whitman vapor-pressure analysis:
   a. Daily record of average tank temperature, established by at least three readings spaced throughout the depth of oil in the tank.
   b. Daily record of average atmospheric temperature and extreme temperature range.
   c. Vapor-pressure values in the Reid scale.
   d. Initial and final tank gaugings as a check on the results by the vapor-pressure methods.
   e. Dates of start and finish of test, and regional location thereof.
   f. Tank dimensions (including slope of cone roofs), kind of roof and roof appurtenances, and painting.
   g. Vent-valve operating pressures.
   h. Degree of filling of tank.
   i. For tests on losses by pumping in, the rate of filling.
5. Present all test results for comparison on the basis presented in this report.

Multicylinder Engine Adaptations in the Oil Industry—L. W. Johnson, before SOCIETY AUTOMOTIVE ENGINEERS, Tulsa Meeting, 1938.

The term multi-cylinder has been rather loosely applied in many instances, but has lately come to mean, in the oil industry, vertical four cycle engines, usually of four or more cylinders. In addition, the term connotes smaller bore, i.e., six inches or less, and spark ignition engines using gas, gasoline, or butane fuels. A number of engines are operating on heavier fuels such as kerosene, in instances where gasoline is not available.

The present report covers, in a general manner, the adaptation of multi-cylinder engines to oilfield use, with particular reference to well pumping service. A brief outline of the history of the use of these engines is included, and so far as the oil industry is concerned this history includes much grief. The principal items of maintenance are discussed, and it is concluded that auxiliary equipment requires continued improvement to meet oilfield conditions. Operating problems concerning lubrication, fuel, cooling and starting, are described. A tabulation of representative approximate specifications of multi-cylinder engines in present use, including other types of well pumping engines, is given. It is believed that multi-cylinder engines cannot be made universally adaptable to oil well pumping, but that their use in this type of service is increasing.

BOOKS

Annual Reviews of Petroleum Technology Vol. 3—published 1938 under the general editorship of Dr. F. H. Garner by the INSTITUTE OF PETROLEUM. London. 490 pages. 10/6.

The third volume of annual reviews of progress in petroleum technology issued for 1937 by the Institute of Petroleum (formerly the Institution of Petroleum Technologists) follows the same general plan as the previous issues. New chapters have been added dealing with "Production Engineering" (compiled by G. H. Scott) and "Aero Engines" (H. S. Glyde). "Regional Geology" is now split into two sections dealing with the United States and other countries, respectively. The section on cracking and polymerization, compiled by Gustav Egloff and colleagues, is the most extended in the book, covering nearly 100 pages. The number of authors cited in the book is well over 2,000. As usual, there is a good index, which makes the work easy to consult.

Chemical Engineering Catalog, 1938—Published 1938 by REINHOLD PUBLISHING CORP., New York, 1,034 pages 11 in. x 8½ in. $3.00.

This 23rd edition of the Chemical Engineering Catalog, which bears the subtitle "The Process Industries' Own Catalog," is larger than ever and continues to be an inclusive source of information on machinery and supplies manufactured and sold in the United States for use in the chemical industries, which of course includes the petroleum industry. The scope of the work is indicated by the fact that the products and services of 527 firms are illustrated and described, in many cases with much detail. Machinery and physical equipment occupy 744 pages. A separate section of 128 pages lists all the chemicals put on the market by American chemical manufacturers whether as raw materials and intermediates or as pure reagents for laboratory use. There is also an extensive list of books on technical chemistry. A complete set of indices facilitates ready reference. Buyers of chemical equipment and supplies can here find practically everything they might want.

Practical Oil Geology, by Dorsey Hager—5th edition published 1938 by MCGRAW HILL BOOK CO., New York, 466 pages, $4.00.

As in the previous editions of this book the author has held to the purpose of assisting oil men to a better understanding of geology in its relations to petroleum. It is naturally impossible to compress all oil geology in a book of 466 pages, but there is at least a minimum of pertinent geological facts which the operator, the petroleum engineer and even the driller should know. The reviewer can testify that the author has shown excellent judgment in selecting and presenting this minimum of petroleum geology. He has wisely restricted himself to a description of general conditions and to showing how these may apply to particular cases. At that, he has achieved the difficult task of compressing an immense amount of material into a small space without any appearance of crowding, which is the supreme test of a writer who has a thorough command of his subject. The book is a real pleasure to read. The reader is taken smoothly through the various theories of the origin of petroleum, stratigraphy and structural geology, prospecting for oil including the applications of geophysics, the factors in drilling and oil production, and numerous other matters of importance. An appendix provides much useful information; there is a list of recent books on oil and general geology and an index.

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Official Figures for Soviet Oil Operation

1938	Production bbl.	Daily Average bbl.	Run to Stills bbl.	Drilling feet
January	17,647,000	569,258	15,882,000	520,000
February	13,591,000	485,393	13,122,000	320,000
March	15,984,000	515,613	14,842,000	340,000
April	17,850,000	595,000	15,850,000	400,000
May	17,580,000	567,097	15,600,000	420,000
June	18,540,000	618,000	15,900,000	550,000
July	18,200,000	587,097	16,800,000	500,000
August	18,000,000	580,645	16,800,000	510,000
September	18,200,000	606,667	16,600,000	500,000
October	18,000,000	580,645	16,600,000	480,000
Total 9 Mos. 1938	173,522,000	570,800	157,996,000	4,640,000
Total 9 Mos. 1937	168,333,661	553,729	155,689,389	5,214,660
Total 1937	202,856,661	555,772	187,121,389	6,244,660
Total 1936	199,634,921	545,450	180,582,274	6,958,916
Quota 1938	244,215,000*	666,066	215,055,000	not available
Quota 1937	234,450,000	642,329	208,285,000	9,240,000
Quota 1936	222,345,000	607,000	182,250,000	7,100,000

*Crude oil and gas

TENSION between the Soviet and Japanese governments, reported last year over the operation of the Saghalin oil concessions, seems to have died down—apparently a working agreement must have been reached between the two interests.

The island of Saghalin was divided into two parts after the Russo-Japanese War in 1904-5; the southern half was ceded to Japan, making it inevitable that clashes would occur between the two nations. Thus it was that during the Bolshevik uprising in 1920 the Japanese occupied the island and during the next five years prospected for oil and coal in the northern part of the island. In 1925 Japan recognized the Soviet government and the Karakhan-Yoshivara agreement was reached; according to which the Japanese returned the northern part of the island and received a concession for prospecting for oil over a period of ten years. In February, 1927, clause was added by which the concession was enlarged.

About this time the Soviets began development of the areas not covered by the Japanese concession. Meanwhile, Japan had already commenced operation of the oil properties under its control—over an area of 400 km. on the east coast of northern Saghalin which was estimated to have reserves of 113,900,000 bbl.—and built a railroad for transportation of the oil. This line was completed in 1932 and links the Okha oilfield with Moscalvo Bay.

In 1928, on the condition that Sakhalineft would deliver to the Japanese a certain quantity of crude over a period of three years, Japan granted the Soviet oil trust a long-term credit to develop production in the Soviet-owned properties under Japanese control. Practically all the oil produced by Sakhalineft during the first few years was delivered to Japan, but since the recent construction by the Soviets of a refinery at Khabarovsk the delivery of Soviet-produced crude to the Japanese has declined. According to Russian statistics the deliveries dropped from 2,465,761 bbl. in 1932 to 1,480,164 bbl. in 1935, while Japanese figures show that they received only 268,000 bbl. in 1937.

Saghalin Oil Output (U. S. Bbl.)

Year	Japanese Concession	Soviet Concession
1926	199,660	Nil
1927	525,950	Nil
1928	696,800	113,900
1929	1,252,900	177,550
1930	1,293,100	645,210
1931	1,842,500	891,100
1932	1,675,000	804,000
1933	1,366,800	944,700
1934	1,246,200	1,276,350
1935	1,005,000	1,675,000
1936	1,005,000	1,842,500
1937	No data	2,010,000

Japan's concession expired in 1935 and was renewed for one year by the Soviet government; it probably has since been renewed for similar periods—although the Japanese pressed for a period of not less than ten years. Another proposal was for Russia to sell them northern Saghalin, which suggestion was flatly rejected because the Soviet is anxious to maintain an oil base of its own in the Far East in view of possible friction with Japan. Present relations between the two nations in regard to Saghalin are difficult to ascertain, as both are reluctant to give any information.

The downward trend in production from the Japanese concession, indicated in the accompanying table, is evidently due to exhaustion.

PRODUCTION

PRODUCTION of crude from all Soviet oilfields during the first six months of 1938 came to almost 16,000,000 tons, which although below plan constituted a considerable improvement over the 14,350,000 tons produced during the corresponding period of 1937. It remains to be seen whether any further improvement will take place during the remaining months of the year to bring output up to plan. According to plan, 33,500,000 tons of crude were to be produced from all Soviet fields. This is 2,000,000 tons above the actual production in 1937 and 1,000,000 tons less than the quota for that year.

Up to June, 1938, production had shown plan fulfillment but during July a decline took place which has not been turned. Certain individual fields are producing in excess of quota, but the Baku fields—mainstay of Soviet output—are still behind.

This shortage is due mainly to deficiencies in drilling and insufficient new wells brought into production. The main season for drilling is over and the coming cold weather will hardly serve to improve drilling operations.

Production had fallen from 100 percent in July of plan to 96 percent in August and 93 percent in October—suggesting that it is likely that Soviet crude oil production for 1938, although below plan, will exceed the 200,000,000 bbl. mark by about 10,000,000 bbl. and set a new record.

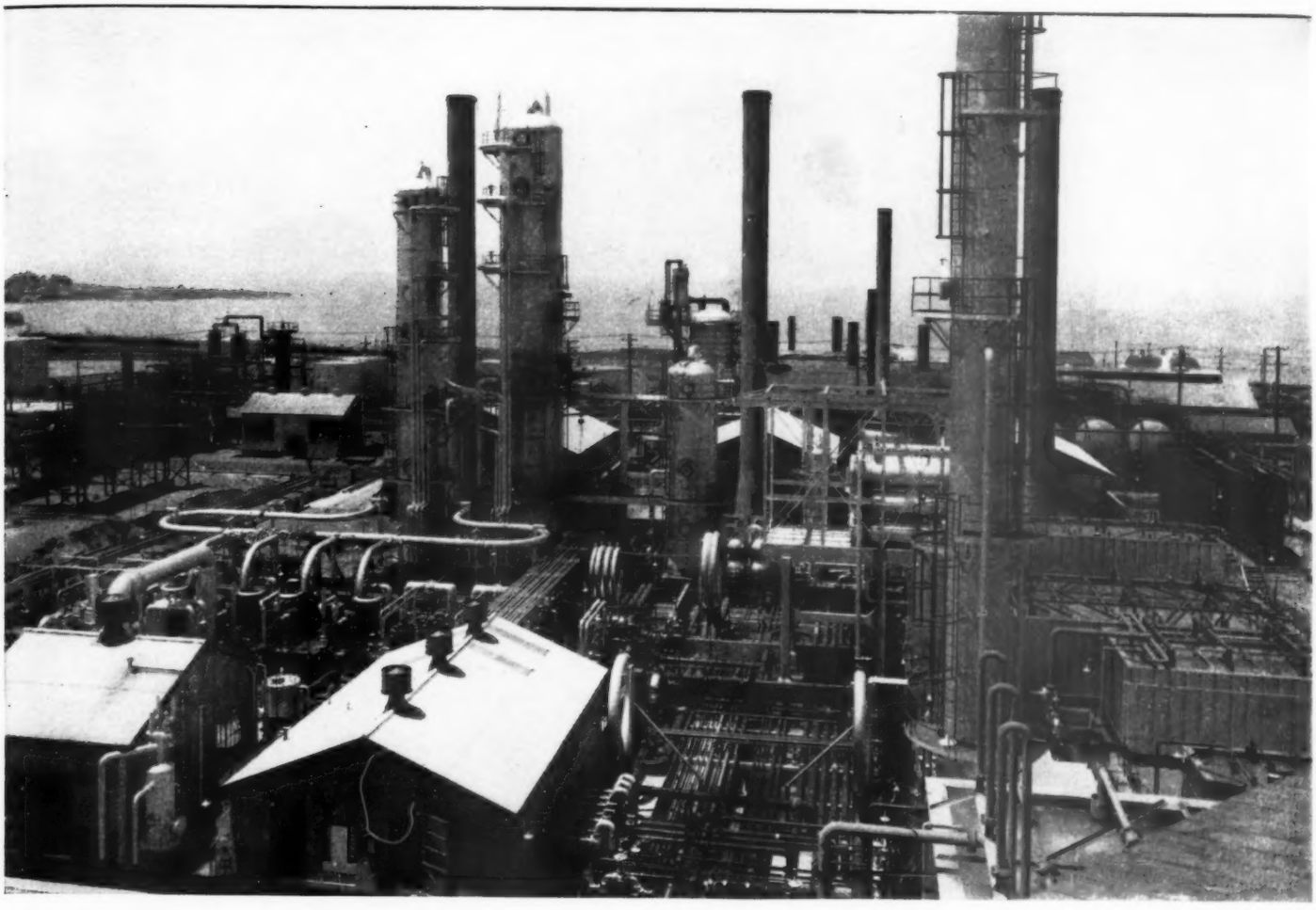
On January 1st, 1938, 5,109 of Baku's 15,346 wells were producing; since that date, during the first three quarters of the current year, 1,850 wells were shut down for cleaning and repairs and scheduled for reinstatement; of these only 711 were brought under production.

MAIKOP GROWS

During 1938 the Maikop field has produced some 20 to 35 percent excess over plan, and prospecting was carried further to the Apsheronsk districts of Shirvansk, Tulski and Varinski with showings which promise to enlarge the oil properties some 200 to 250 km. of lands from Shirvansk down to the Taman peninsula on the Azov Sea.

The present operations at Maikop together with the increases expected during 1939 are bound to bring the oilfield to the fore so as to surpass the Grozni oilfield group—making Maikop second only to Baku in the Caucasus. Grozni now produces about 3,500,000 tons annually against some 2,500,000 tons by Maikop.

The spontaneous increase of production at Maikop has seemingly caught the operators unawares, and lack of adequate roads has further aggravated the lack of



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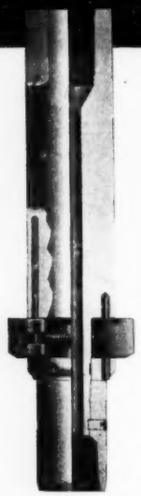

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sufficient storage capacity. The fields are connected by pipeline with the Krasnodar refinery and the Grozni-Tuapse system, but these facilities are incapable of handling the increased crude oil output.

Maikop's production of 1,500,000 tons of crude oil during 1937 was the source of about 350,000 to 400,000 tons of gasoline, and 1938 production is expected to double this amount. Planned production is to be exceeded by about 500,000 tons, and the Maikop operators hope to increase the drilling speed from 2,100 to 2,300 ft. per table/month.

EXPORTS

Since the simplification of official statistics on Soviet oil exports by the elimination of details it is impossible to ascertain what quantities of individual refined products were shipped out of the country.

Soviet oil exports have been on the decline ever since 1932, when a peak of 5,000,000 tons (2,000,000 tons gasoline) were shipped—the total for 1938 is bound to be less than 1,000,000 tons while Russia is likely to continue importing gasoline.

Factors contributing to the dwindling of Russia's export trade include the fall in Grozni output, the expansion of industry and mechanization of agriculture, greater devlopment of land and air transport, and the increased requirements for national defense. The planned increase in Soviet oil production has not materialized and the industry has been unable to keep up with consumption.

Soviet Oil Exports

Destination:	Jan.-June 1938	(Tons)	Jan.-June 1937
England	149,050		176,750
Germany	55,855		159,624
France	50,015		138,466

Export:	Jan.-July 1938	(Tons)	Jan.-July 1937
Crude oil	76		47,897
Refined products	641,199		1,186,559
Total exports	641,275		1,234,456
Value	52,780,000	(Rubles)	88,800,000

Decrease:
Quantity ..... 48.1 percent
Value ..... 40.6 percent

Soviet Gasoline Imports

Period	Tons
Jan.-July, 1938	49,248
Jan.-July, 1937	70,585
Total, 1937	109,647
Total, 1936	47,306

Soviet exports of crude oil have in 1938 fallen to a mere trickle, while trade in refined products is a mere half of that during the corresponding period of 1937. It is evident that export purchases by Scandinavian and other European countries has been greatly diminished. Of Soviet Russia's remaining business, some 25 percent is with England and about seven and eight percent, respectively, with France and Germany.

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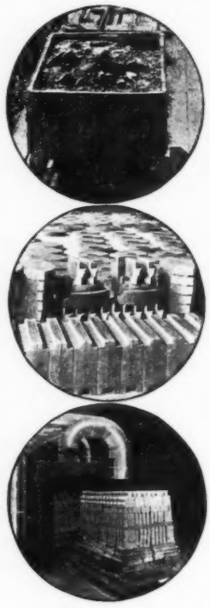
AYRSHIRE FIRECLAYS has proved very suitable for OIL FIRING



A modern plant provides for hand moulding, stiff mud pressing or dry pressing, as required, while tunnel kiln firing contributes to the maintenance of a high standard for shape and finish.

A range of grades is offered including—

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"DOUGLAS A" (43/44% alumina) for solid built walls and sprung arches.

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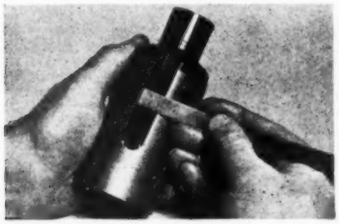
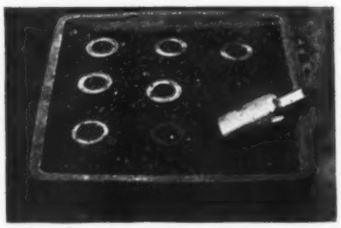
1. Axelson Heavy Duty Cages are formed from bar stock after which milled areas between the wings are produced on duplex milling machines.

Only a part of a pump, but note the care given to it in each of the thirteen operations illustrated, out of a total of fifty required. Dozens of other parts are needed to complete the pump, and each part requires many honest and unhurried operations—hundreds in the finished unit.

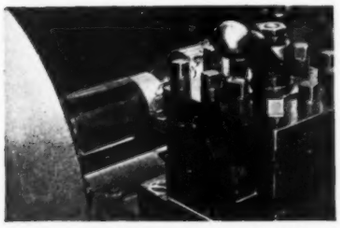
Equipped with the finest tools and machinery, Axelson factories are keyed to precision production. Here a thousandth of an inch is a big dimension. Not only are important parts checked to close tolerances, but also the tools that make them are being constantly inspected for accuracy. That's why it is safe and economical to buy Axelson products—anywhere on earth.



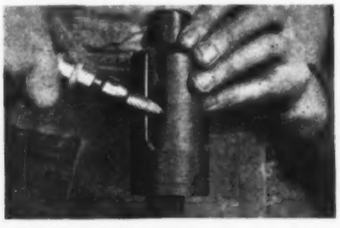
2. Semi-finished bore and measurements of milled areas are checked for accuracy by inspectors.



3. The semi-finished cages are carburized by pack hardening in a solid carbonaceous material.



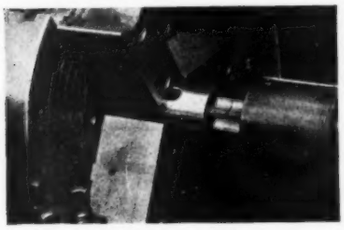
4. After carburizing the outside surface, the main body and the pin of the cage are turned to remove the carburized surface.



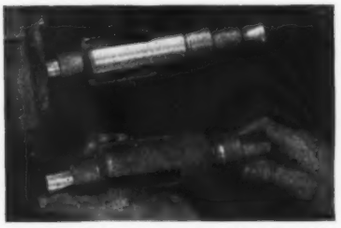
5. The carburized surface for the threaded portion on the inside is removed by boring. Burrs are removed with rotary file.

6. At this point of processing, cages are heated in an electric furnace to proper temperature, and quenched in oil.

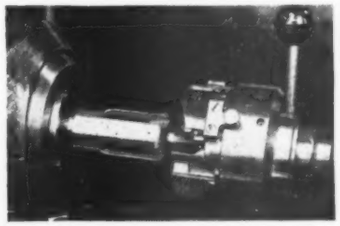
7. After hardening by quenching, the cages are drawn in a Homo electric furnace and checked for proper Rockwell hardness.



8. Cage threads to API specifications are tapped in lower end of cage after cage has been finish reamed to size.



9. The outside diameter of both body and pin of cage are finish ground to size on center and checked for proper tolerances.



10. API specification sucker rod pin threads are produced on cage pin and gaged with both "Go" and "No Go" ring gages.

11. Inside diameter of wings is ground t permit diametral clearance of .040" to .050 when using standard API ball.

12. Checking radius of pin collar with precision radius gage is included as one of the many final inspections.

13. Cages are stamped, washed, oiled an then placed on steel shelving ready for a sembling in pumps or shipment as spare

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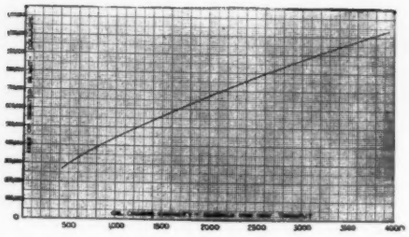
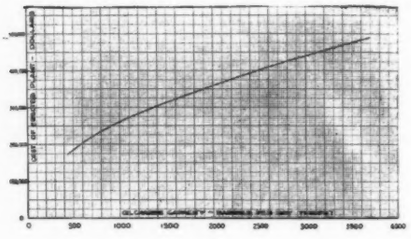
CORRECTION

IN THE ARTICLE, "Cost and Extent of Solvent Refining and Dewaxing" in the Annual Refinery Issue of WORLD PETROLEUM, the captions for the graphs showing cost in relation to charging capacity for benzole ketone dewaxing and furfural plants were placed under the wrong charts. They are reproduced herewith correctly labled, with apologies to the authors.

Installation costs of a benzol ketone dewaxing plant (below).



Installation costs of a furfural extraction plant (below).



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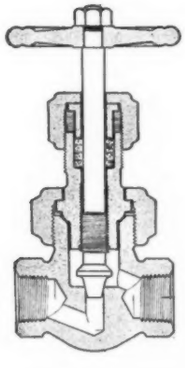
Products		Nov. 9	Nov. 16	Nov. 23	Nov. 30
		Cents Per Gallon			
GASOLINE:	U.S. Motor	4⅜	4⅜	4⅜	4⅜
	64/66-375 E.P.	4⅜	4⅜	4⅜	4⅜
	59 Octane and below	4⅜	4⅜	4⅜	4⅜
	65 Octane and above	4⅝	4⅝	4⅝	4⅝
AVIATION GASOLINE:	Gulf Export in cargo lots	8¼	8½	8½	8½
KEROSENE:	44 w.w.	4⅛	4⅛	4⅛	4⅛
	41/43 w.w.	3⅞	3⅞	3⅞	3⅞
	41/43 p.w.	3⅞	3⅞	3⅞	3⅞
GAS OIL:	43 Diesel Index and below	3⅜	3⅜	3⅜	3⅜
	43/47 Diesel Index	3⅜	3⅜	3⅜	3⅜
	48/52 Diesel Index	3½	3½	3½	3½
	53/57 Diesel Index	3⅝	3⅝	3⅝	3⅝
		Dollars Per Barrel			
FUEL OIL:	Bunker C	75	75	75	75
	Cargo lots	62	65	65	65
	Diesel oil	1.55	1.55	1.55	1.55
		Cents Per Gallon			
LUBRICATING OIL:	Bright Stock No. 8	21½	21½	21½	19½
	Bright Stock No. 6½	21½	21½	21½	21½
	600 Warren E	20½	20½	20½	20½
	600 Unfiltered s.r.	15½	15½	15½	15½
(New York Export Market)	650 Unfiltered s.r.	17½	17½	17½	17½
	600 Flash s.r.	18	18	18	18
	630 Flash s.r.	20½	20½	20½	20½
	Neutral 200 No. 3	22½	22½	22½	22½
	Neutral 150 No. 3½	21½	21½	21½	21½
(South Texas Export Market)	Red oil 500 No. 5-6	7½	7½	7½	7½
	750	8¼	8¼	8	8
	1200	8¾	8¾	8⅜	8¾
	Pale oil 500	7¾	7½	7½	7½
	750	8¼	8¼	8	8
	1200	8¾	8¾	8⅜	8⅜
		Dollars Per Barrel			
CRUDE OIL:	East Texas delivered at Gulf for export	1.19	1.19	1.19	1.20

DROP FORGED STEEL

New METER VALVES

UNION BONNET TYPE



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- ○ Hexagon body ends for easy line assembly.
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- ○ Stem can be easily reground or replaced. Valve can be repacked under pressure.
- ○ Recommended for 900 lbs. W. P. @ 750 Deg. F. or 1500 lbs. non-shock cold working pressure.
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World Petroleum (including Petroleum Equipment Exporter), Vol. 9, No. 13, December, 1938. Entered as Second Class Matter, March 19, 1938, at the Post Office at Hoboken, N. J., under the Act of March 3, 1879. Additional entry at the Post Office at Brooklyn, N. Y. Published monthly November to September, semi-monthly in October, by Russell Palmer at 95 River Street, Hoboken, N. J.

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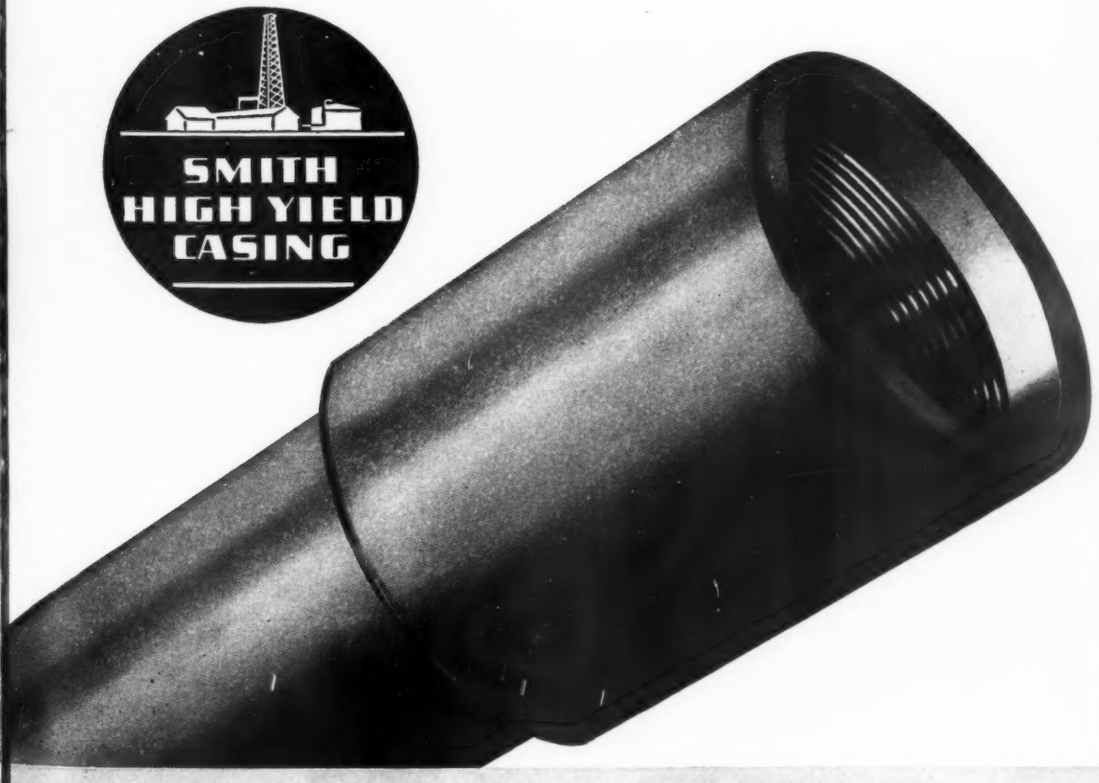

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3. Attain greater depths with equal safety.

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*Because threads are more accurate, you get—

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2. Greater running speed.

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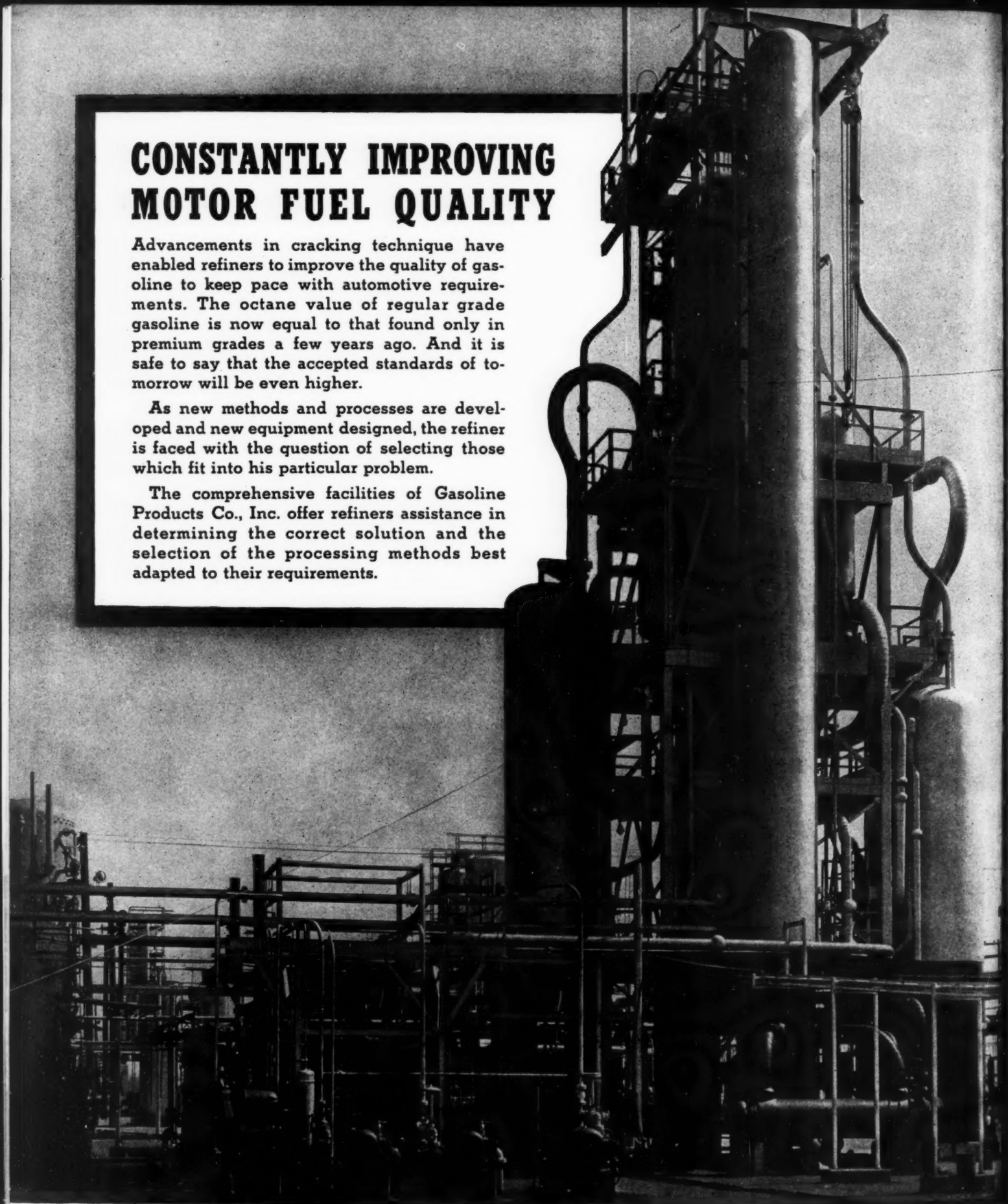

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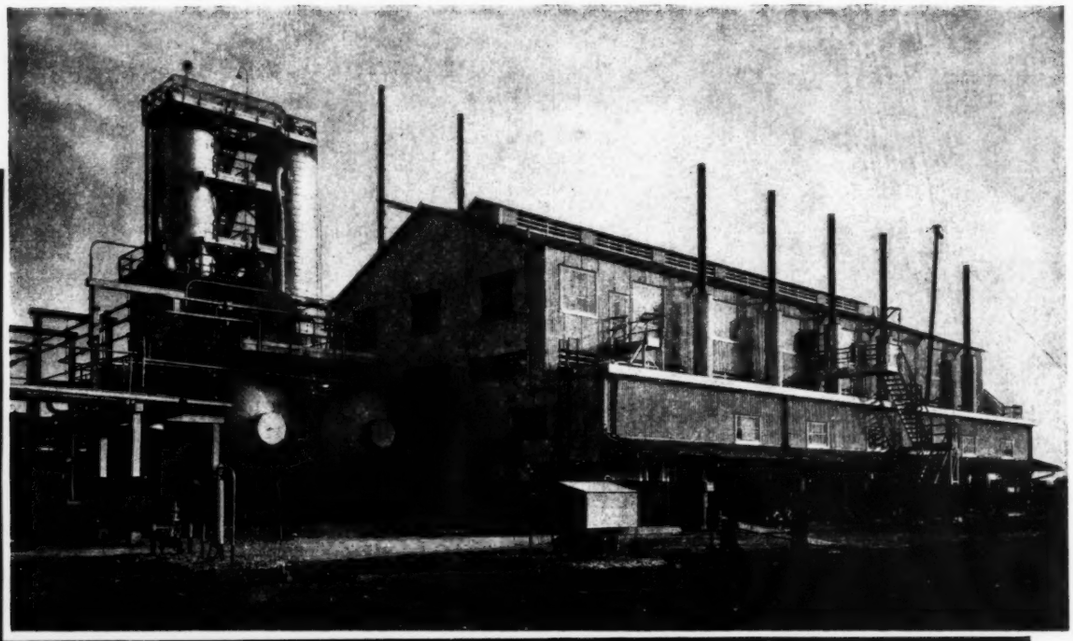

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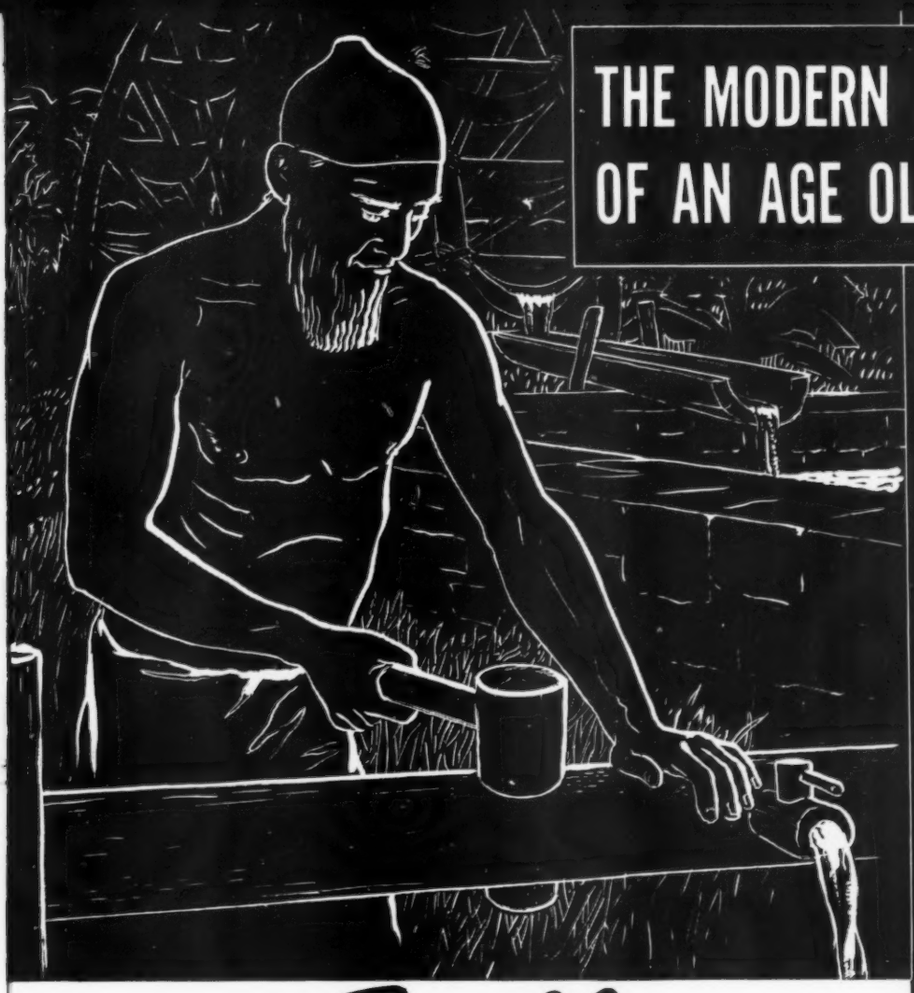

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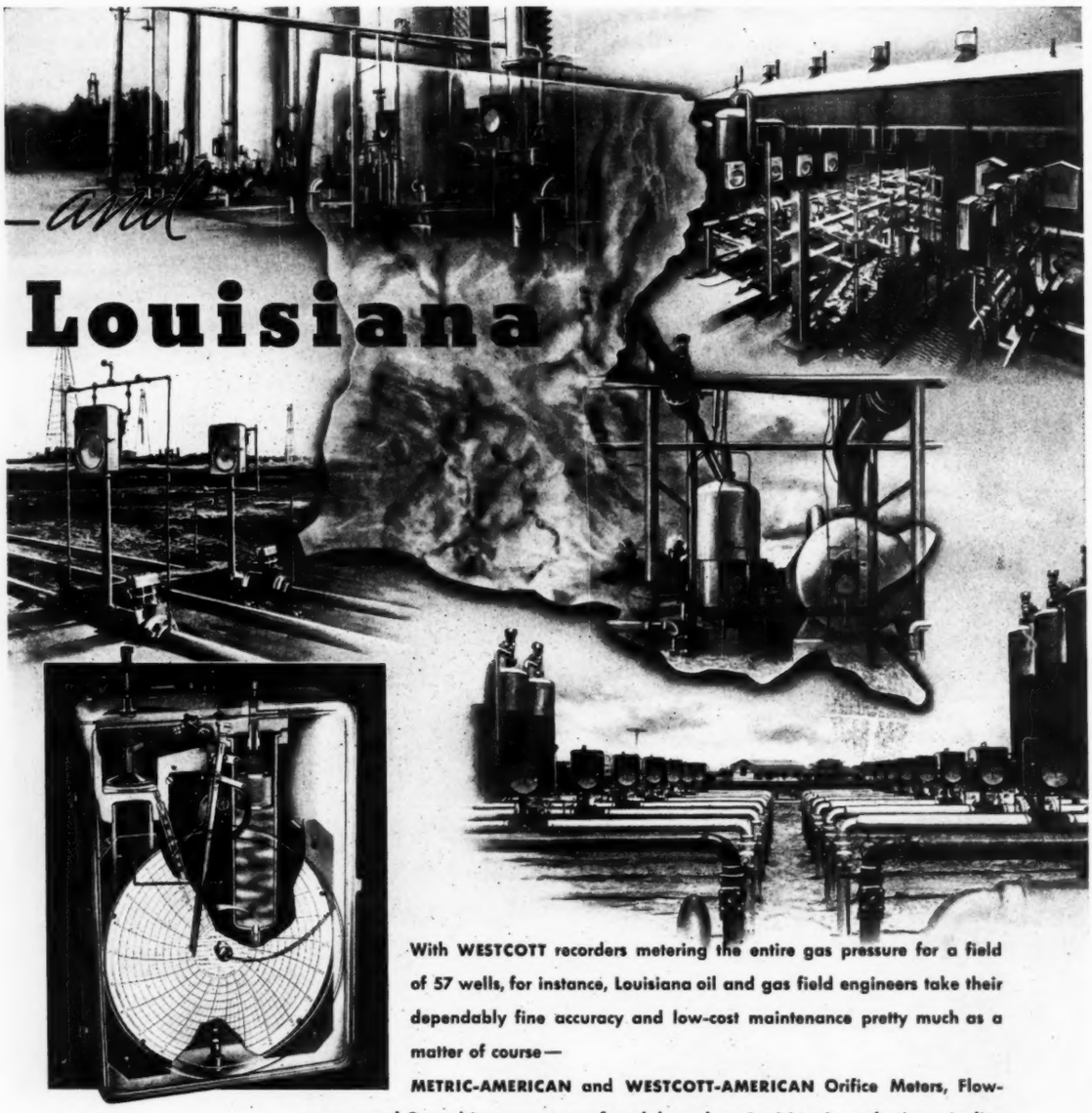

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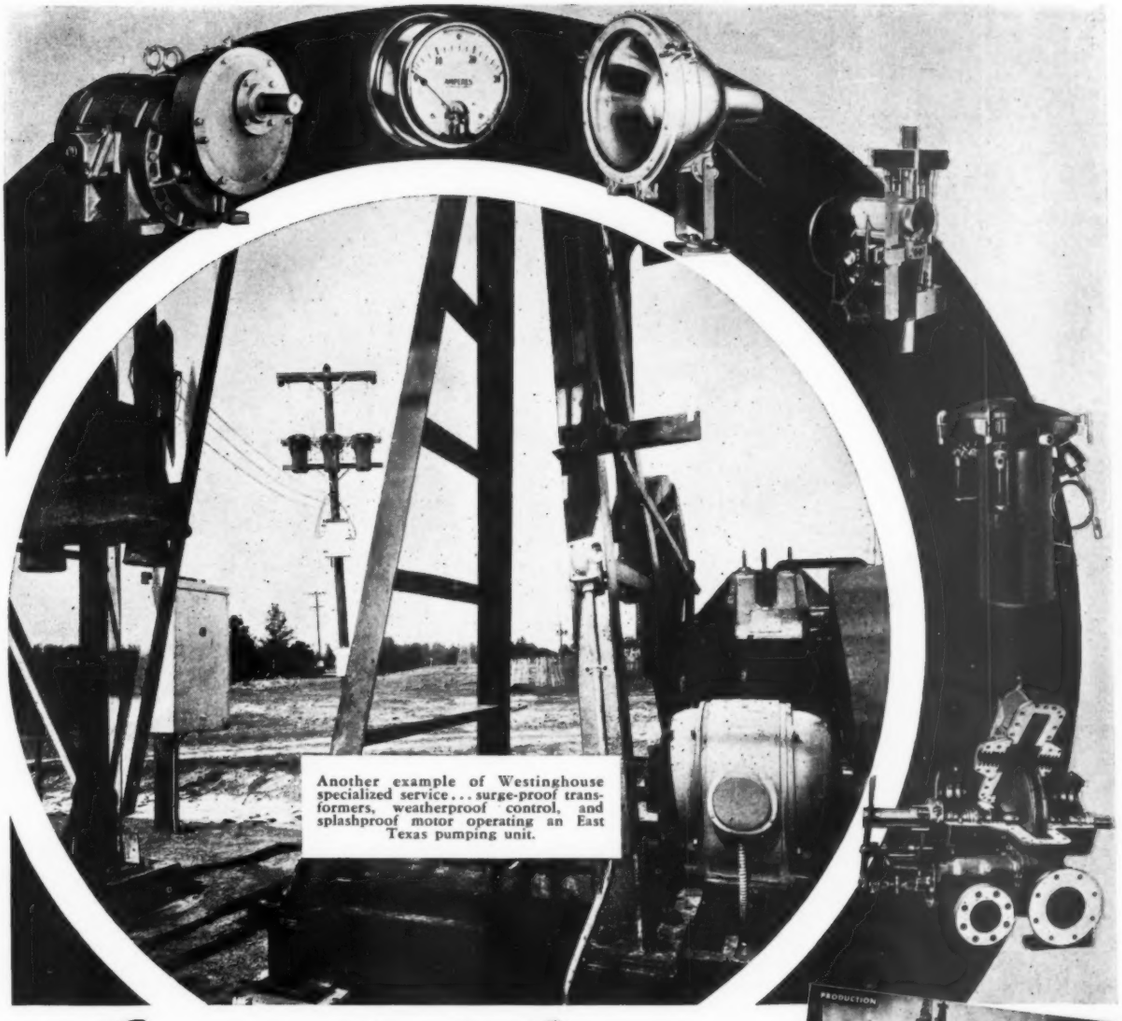

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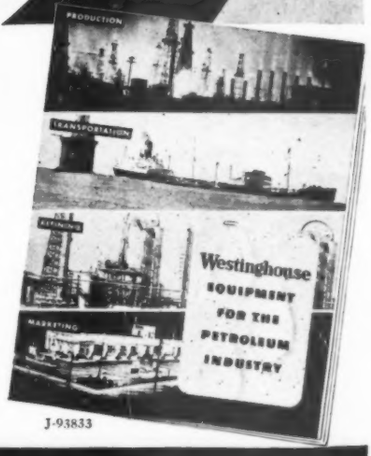

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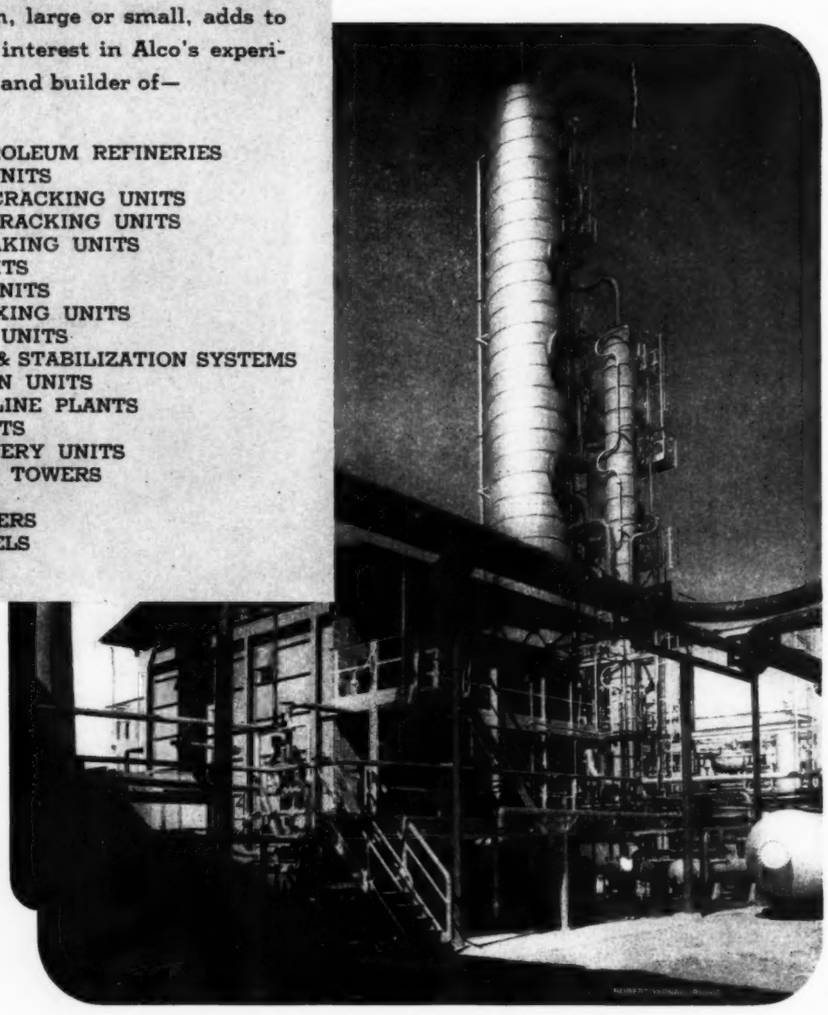

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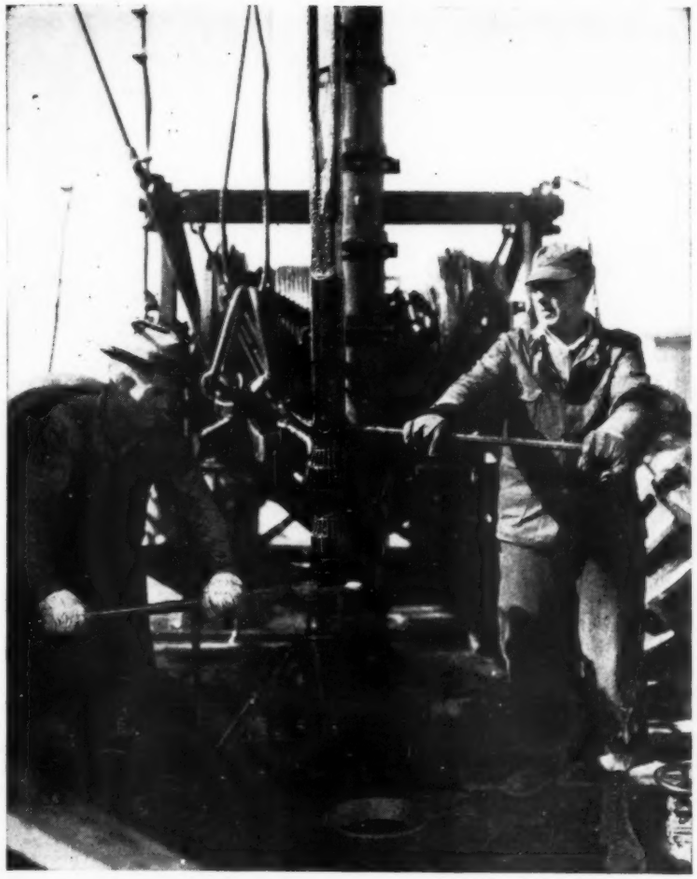


Cup Assembly is Removed with maximum speed and ease, by merely unscrewing the retaining nut at bottom of swab. Many operators, instead of using wrench at top of swab, simply insert a bar in the fluid by-pass openings in mandrel, as here shown.

Ready to Run In, on well shown at left, with 4" Guiberson Type "K" Swab. Jim Sloan, right, is a driller of long experience in West Virginia, Oklahoma, and Illinois, where this picture was taken, near Centralia. At left is Fred Rice, tool dresser.

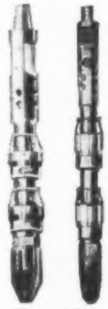
Guiberson Type "K" Tubing Swabs promote good humor because they are trouble-proof. In center of photograph is Bob Garden of R. E. Garden & Son. Well is in Rice County, Kansas. The Guiberson Corporation will pay $5 to the first person who sends in the correct names of the two unidentified men in this photograph.

"A FULL LOAD EVERY TRIP — AND TROUBLE PROOF," SAYS JIM SLOAN

JIM SLOAN—driller for a major oil company, in the Illinois Field — has been using and choosing Guiberson Swabs for many years. He tells us that he prefers the Guiberson Swab because, (1) it raises a full load, the flexible cups expanding and contracting to make up for reasonable variations in casing diameter; (2) because he finds it trouble proof, as its flexible cups never stick going in, or hang coming out, and it runs in at maximum speed; (3) because Guiberson, since they first brought out the swab, have continued to improve it. "The Type K is the best swab I've ever used," says Sloan.

Bob Garden, shown at left (center) with a Guiberson Type "K" Tubing Swab, is another chooser and user of Guiberson Swabs.

Guiberson Swabs today do more than 90% of the world's swabbing, because (1) they raise a full load, the fluid pressure working with the cups to secure tight contact with the casing or tubing walls; (2) cups won't stick, their flexible rims yielding to pass projections and paraffin; (3) running in, fluid and gas easily by-pass flexible cups, assuring maximum speed; (4) cups have maximum life, due to flexibility, the protection afforded by steel wires, and the patented feature of molding the cup around a steel insert; (5) same size cup will fit slightly varying diameters of pipe; (6) cups are made of a special rubber composition, highly resistant to oil deterioration; (7) unlike solid rubbers, cups expand to fit the pipe, after being worn in use.



Type "K" Casing and Tubing Swabs —Patented

For complete information see Composite Catalog, pages 790 to 793. The Guiberson Corporation, 1000 Forest Ave., Dallas, Texas. Export: I. Frank Brown, 30 Rockefeller Plaza, New York. California: W. R. Guiberson Co., 723 E. Gage Avenue, Los Angeles.

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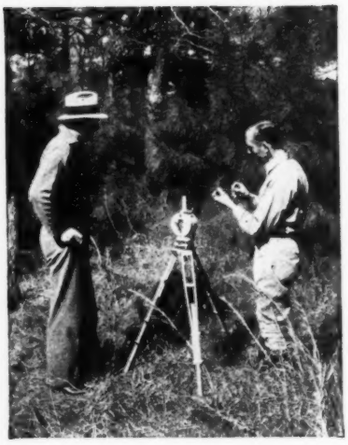

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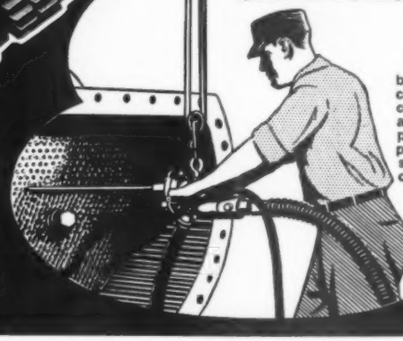

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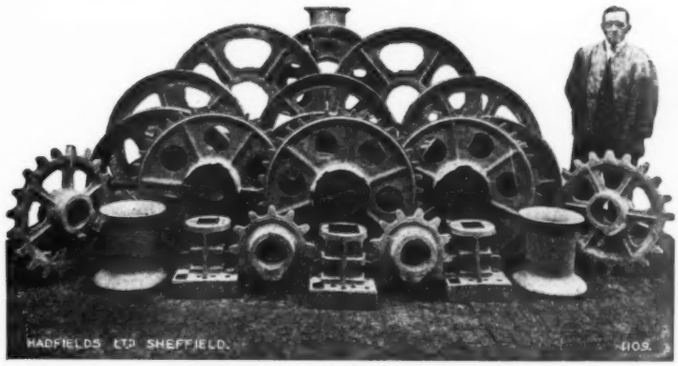

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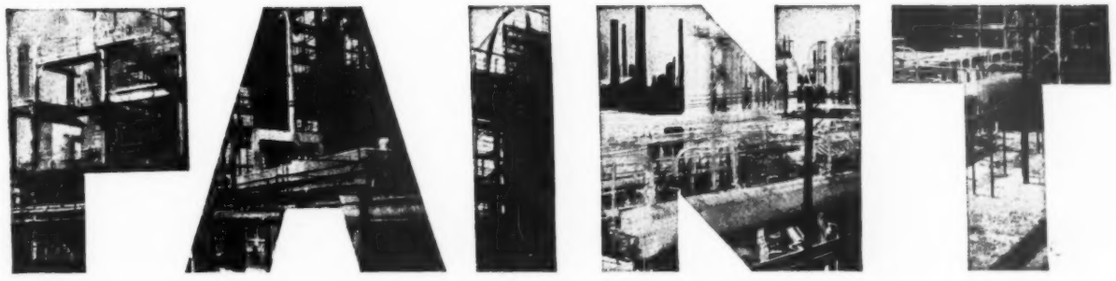

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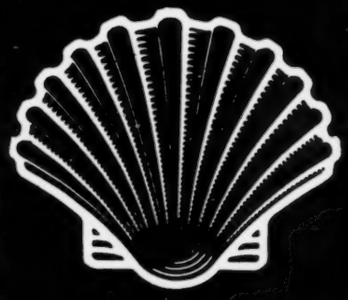

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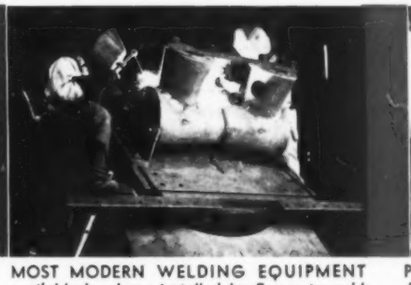

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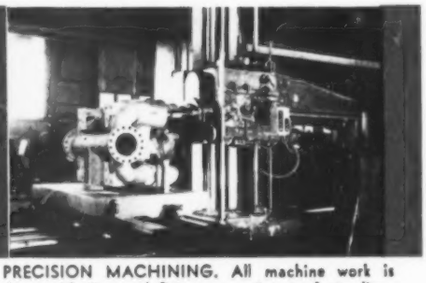

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